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ARMY AIR FORCES HISTORICAL STUDIES: NO. 51

THE MAINTENANCE OF ARMY AIRCRAFT IN THE UNITED STATES

1939-1945

(General Development and Policies)

The original of this monograph and the documents from which it was written are in the USAF Historical Division, Archives Branch, Bldg. 914, Maxwell Air Force Base, Alabama.

AAF Historical Office
Headquarters, Army Air Forces
August 1946

FOREWORD

This study of the maintenance of Army aircraft is one of a number of histories dealing with materiel activities of the Army Air Forces during World War II. For the most part, the study was written at Wright Field, headquarters of AAF services and procurement agencies, by Capt. Robert W. Ackerman of the Materiel Section, AAF Historical Office.

The following broad phases of aircraft maintenance are covered: maintenance practices before 1939, the development of headquarters control of maintenance during World War II, the expansion of the air depots, the experiment with the subdepots, contract overhaul agencies, wartime maintenance policies, Production Line Maintenance, and inspection, minor repair, and overhaul procedures.

Readers familiar with this subject are invited to forward criticisms and suggestions to the AAF Historical Office. For this purpose perforated pages are attached at the back of the study.

C O N T E N T S

ILLUSTRATIONS

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The Maintenance of Army Aircraft in the United States, 1939-1945

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INTRODUCTION

Success in the air war depended very heavily on the proper maintenance of aircraft in the theaters of operations and no less on the flying condition of trainers and other aircraft in the Zone of the Interior. The present history is primarily concerned with the system of maintenance which provided for the upkeep of aircraft based in the United States during the period 1939-1945. More specifically, it traces the development of wartime policies and techniques pertaining to maintenance and also the enormous expansion that characterized all elements of the armed services during these years.

As used here, the term "maintenance" is meant to include all operations necessary to keep an airplane in safe flying condition: servicing with fuel and oil, periodic inspections, minor repair, and major repair or overhaul. There were several levels or "echelons" of minor repair, the distinction being based on the amount of work, equipment, and personnel required. Prior to 1942, major repair or overhaul was known as "third echelon" maintenance; thereafter as "fourth echelon."

All technical and much supervisory responsibility for the Army Air Forces system of maintenance, during the greater part of the period 1939-1945, rested on the Air Service Command, later combined with the Materiel Command to form the Air Technical Service Command. To a considerable extent, then, this history deals with the activities of the Air Service Command and its successors, but it also embraces the

staff functions of AAF Headquarters pertaining to maintenance and the performance of the lower echelons of maintenance by the other commands and the air forces.

Emphasis is placed on the actual work of maintenance and the evolution of policies and procedures rather than on details of headquarters organization and administration. On the other hand, the functioning of the headquarters which administered maintenance must receive some attention if the nature or effectiveness of the basic policies is to be understood.

Again, the magnitude of the whole subject of maintenance makes it necessary to confine the study to procedures relating principally to the airplane structure, or airframe, and to the engine. The complicated repair and overhaul of the numerous items of associated equipment, such as gunnery, bombing, photographic, radio, and radar [1] equipment, can scarcely be given a full treatment here, although the general development of those activities is indicated from time to time. In the account of airplane and engine inspection and maintenance, the subject is further limited to the operations applying to a particular airplane--the B-17. This model was chosen because its all-metal semimonocoque construction and radial engines present maintenance problems typical of combat aircraft of World War II. Furthermore, the B-17 Flying Fortress was one of the most numerous of all the combat aircraft in the Army Air Forces, and during the long siege of Festung Europa for strategic bombing purposes.

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1. See ATSC historical monograph, "Radio and Radar Supply, Maintenance, and Training by the Air Service Command: 1940-1 September 1944," [hereafter referred to as ASC Signal Corps Activities].

The special maintenance practices adopted for jet-propelled aircraft, like the P-59A and the P-80, are omitted from consideration here because these aircraft were not sufficiently developed to be thrown into combat. Also, the maintenance of the comparatively new B-29[2] and of gliders, since special problems were involved, is not discussed here.

The maintenance system in force at the beginning of 1939 was designed to keep in flying condition approximately 2,000 airplanes and double that number of engines. The maintenance system in the continental United States from 1939 to 1945 had to provide at once for the immense expansion in the numbers of aircraft and for the many new and complicated developments in flying equipment. The present history records the way in which this double challenge was met by the Army Air Forces.

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2. An ATSC monograph dealing with the special problems presented by the supply and maintenance of the B-29 is in progress.

Chapter I

MAINTENANCE ACTIVITIES PRIOR TO 1939[1]

The maintenance activities developed in response to wartime conditions can best be understood against the background of Air Corps practices of the preceding years. The principal elements of the maintenance organization were the Field Service Section of the Materiel Division, and the engineering departments of the four continental air depots: San Antonio, Fairfield, Rockwell, and Middletown. The experimental engineers at McCook Field, later at Wright Field, cooperated closely with the Field Service Section by carrying on research on maintenance problems. Policy making was one of the most important functions of the Materiel Division. Information on the basis of which maintenance policies were formulated reached the Materiel Division from the depots and stations in the form of various operational and cost accounting reports and also in the verbal reports of engineering personnel at the annual Engineering Supply conferences. Especially valuable as sources of information about maintenance were the Unsatisfactory Reports and the reports embodying the results of the regular visual inspections of all aircraft, such as Form No. 41B.

On such a basis, the Materiel Division issued Circulars, Technical Letters, Technical Orders, and other directives prescribing the general

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1. This chapter is a summary of an ATSC historical monograph, "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," in AFSHO files.

organization and operation of the depot and station engineering departments and setting forth detailed instructions for correcting specific difficulties and performing particular jobs. Matters of broad policy, such as the obsoletion of aircraft, were determined by the Office of the Chief of the Air Corps (OCAC) and the War Department. The policies most important to the present study are those relating to depot organization, to airplane and engine inter-overhaul periods, and to the echelons of maintenance. The original overhaul policy directed that airplanes be sent to the depots when, in the opinion of the station engineering officers, they stood in need of rebuilding. Beginning in 1930, however, definite inter-overhaul periods were set for the various models of airplanes and also for engines. These periods increased from 12 to 24 months during the next six years, but in 1937 there was a return to the older plan of overhauling airplanes only when visual inspections revealed the need for such work. Inter-overhaul periods for engines increased from 125 up to 400 hours of flying time by 1939. In actual practice, these limits were often exceeded because of the need for economy.

Inspection of aircraft was provided for by the system of maintenance inspection inaugurated in 1927. Inspections and preventive maintenance operations were prescribed at first on a daily-weekly-monthly basis, but in 1932 and 1933 the change to a flying hours basis was effected. In 1939, the schedule for both airplanes and engines called for daily, preflight, 20-hour, 40-hour, 80-hour, and weekly maintenance inspections.[2]

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2. TO 00-20A, 1 Oct. 1938, Sec. VII.

The basic steps in the overhaul of the old wood-fabric airplanes were dismantling, including removal of the fabric, inspection and repair of the fuselage and wing structures, alignment of the fuselage, coating the wooden structure with glue sizing, re-covering with fabric, doping and painting the fabric, reassemoly, and flight test. Overhaul of metal-fabric airplanes, which began to supersede the older type in 1927, was substantially the same as for the wooden type except for the process of repairing the steel or duralumin tubing of the fuselage.[3] All-metal monocoque construction, which began to appear early in the 1930's, required a somewhat more elaborate procedure involving cleaning, preliminary inspection, dismantling, inspection and repair of the various assemblies, reassembly, painting, and flight test.[4] The great superiority of metal-fabric and all-metal over wood construction, so far as maintenance engineering was concerned, was recognized at an early date. This superiority is evident in the extensions of the inter-overhaul periods.

Although very great improvements were brought about in engine design during the years 1921 to 1939, the fundamental process of overhaul was not much affected. That is, whether the engine was a World War I Liberty of 400 horsepower or a Wright Cyclone of 820 horsepower, overhaul involved the following steps: preparation, including draining, cleaning, mounting on an overhaul stand; preliminary inspection and repair of subassemblies; general assembly; final assembly; inspection and timing; and block test. On the other hand, various new features, such as the use of stellite facings on valve and valve inserts, and nitrided surfacing of cylinder walls required special treatment at overhaul.

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3. "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," pp. 30-39.
4. Ibid., pp. 39-44.

The engineering personnel at the four continental depots, at which the major overhaul and repair of all Air Corps airplanes and equipment was performed, numbered from 1,200 to 1,700 during the period 1921 to 1939. The workmen in the shop section were assigned to various units, such as aero repair, engine repair, and machine shop, according to their skill and experience. From 1931 to 1939, the average number of airplanes overhauled annually per depot was 166, although after 1935, overhaul figures for all depots tended to drop lower year by year. In fact, after that date only the San Antonio Air Depot overhauled a number of airplanes larger than the nine-year average of 166. The annual average per depot for engine overhaul was approximately 500. Again, the San Antonio depot led in the scope of operations, passing the 1,000 mark in both 1934 and 1939.

The average costs per airplane and engine overhaul increased considerably from 1931 to 1939. For airplanes, this increase amounted to 96.5 per cent, and for engines, 52.7 per cent. Such advances in costs are to be explained by the more complicated construction of airplanes and engines and by the large number of accessories that formerly had not been necessary as flying equipment.

Perhaps the trend of greatest significance to be discerned in the study of maintenance from 1921 to 1939 is the development of preventive measures. The Air Corps sought to anticipate and prevent failures and malfunctioning by establishing a flexible maintenance inspection system which could be extended or modified on short notice to cover items likely to become sources of trouble.

Chapter II

MAINTENANCE CONTROL

The Expansion of the Air Arm

The best index to the unexampled growth of the Army Air Forces and also to the magnitude of the problem of maintenance is the steep rise in airplane inventories from 2,422 in 1939 to 78,757 in 1944. Of the 1944 inventory 52,918 airplanes were based in the continental United States (see Figure 1).[1] The decline in airplane inventories after 1944 was a result of the lowering of the procurement rate. The total engine inventory, taking account of installed, serviceable, and reparable engines, was approximately four times as great as the airplane inventory. Thus, as of 30 June 1945, when the airplanes in the United States numbered 38,328, there were 159,881 engines within the continental limits.[2]

The acquisition of flying equipment in ever-increasing volume entailed a corresponding increase in maintenance facilities. In 1939, a plan of expansion was drawn up that was to provide sufficient facilities for the 5,500-airplane program then in effect. That is, estimates were made of the numbers of aircraft of each type that would normally be in

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1. It is unnecessary to trace here the various stages in the growth of American air power from the 25-Group Program of April 1939 to the 273-Group Program of June 1943, inasmuch as a full account is available in other histories. See especially draft AAF Historical Study, "Airplane Production, Programs, and Controls for the AAF, 1939-1945."
2. Statistical Summary of ATSC Activity, Control Room, Hq., ATSC.

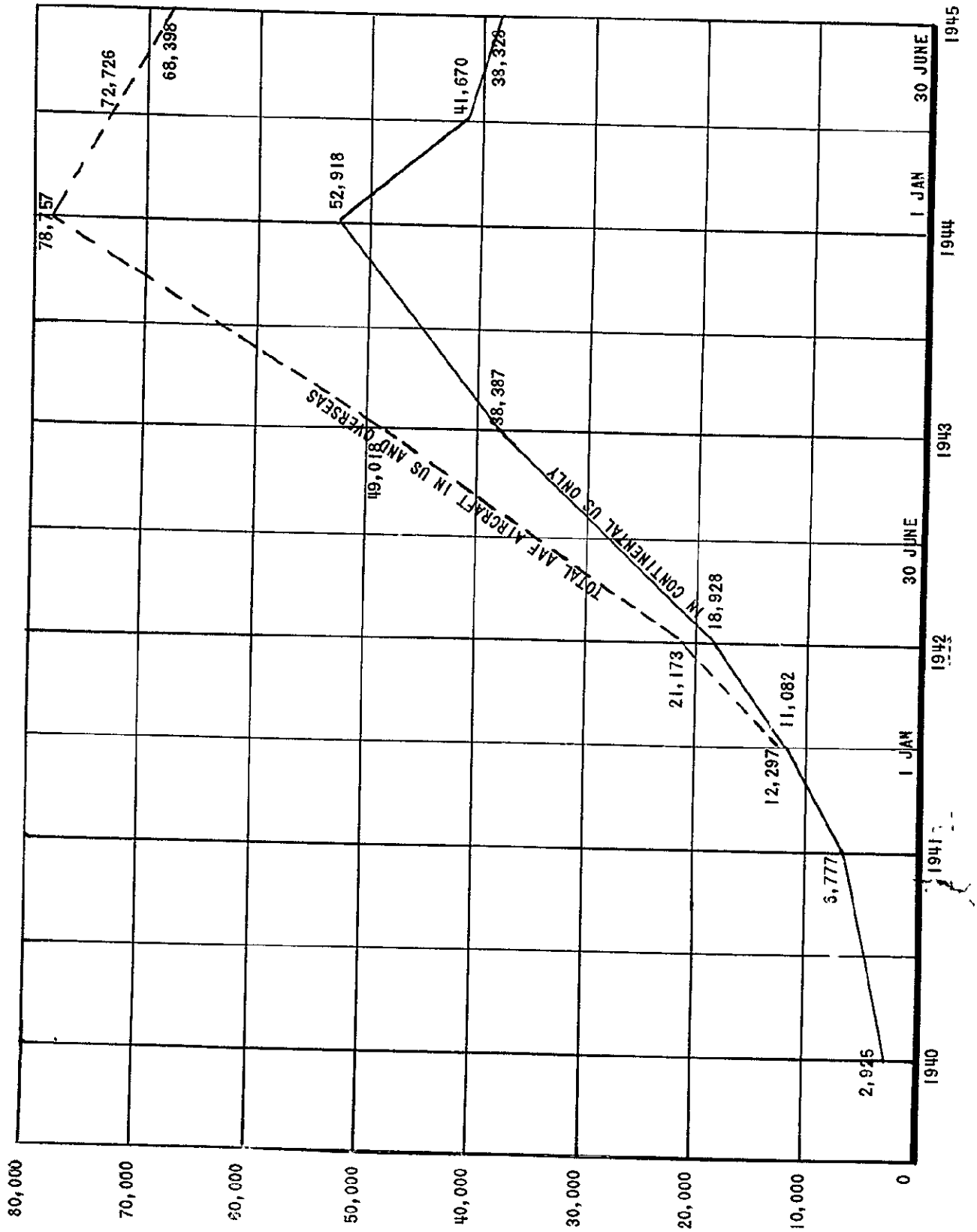

FIGURE 1

the station or depot shops for inspection, repair, or overhaul at any one time, and from these figures the total maintenance requirements were calculated.[3] As larger and larger procurement programs succeeded each other, maintenance requirements were likewise increased.

AAF Headquarters Control of Maintenance

With the considerable increase in the number of airplanes and engines to be kept in flying condition, the AAF Headquarters organizations exercising over-all control of maintenance had also to be expanded and modified. Traditionally, the Chief of the Air Corps was charged with the responsibility for the maintenance of all aeronautical equipment and supplies used by the Air Corps, except those furnished by the Other Arms and Services, and with the technical supervision of methods of maintenance by all activities of the air arm including those not directly subject to his command--namely, the GHQ Air Force units. Such technical supervision consisted of inspections and the instance of instructions pertaining to engineering methods and procedures.[4]

Although the Chief of the Air Corps delegated the operation of the maintenance system to the Chief of the Materiel Division, he retained general control through one agency or another. This surveillance, prior to 1939, was exercised through a liaison office in the Supply Division, OCAC, known as Field Services.[5] With the elimination of certain

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3. See ATSC historical monograph, "History of the Acquisition of Facilities for the Air Service Command," p. 14; memo report, Maintenance Requirements, 5,500 Airplane Program, prepared by the Budget Office, Mat. Div., 26 Jan. 1940, in AAG 452.1-52B, Repair of Aircraft.
4. AR 95-5, 2 Oct. 1937, par. 2b. No changes in maintenance responsibilities were introduced in the subsequent revision, AR 95-5, 8 June 1940.
5. AAF Historical Studies: No. 10, Organization of the Army Air Arm, p. 37.

functions of the Supply Division in September 1939, however, the Chief of the Materiel Division was moved from Wright Field to Washington, where he served as principal adviser to the Chief of the Air Corps on technical matters. Because the Chief of the Materiel Division and his staff were in closer contact with the operating elements at Wright Field than the old Supply Division had been, this change improved liaison and brought better informed supervision. At the same time, the Materiel Division at Wright Field, together with the four air depots and the Procurement Districts, was placed under the supervision of the Assistant Chief, Materiel Division.[6] Maintenance supervision by the Chief of the Air Corps consisted principally in coordinating technical instructions prepared by the Materiel Division, initiating broad changes in policy, and deciding upon important measures proposed by Wright Field.

Upon the creation of the Army Air Forces, 20 June 1941, ultimate responsibility for maintenance passed to the Chief, Army Air Forces. The Chief of the Air Corps continued his supervision and technical control of maintenance through the Materiel Division; and the Commanding General, Combat Command, formerly the GHQ Air Force, controlled maintenance activities at his bases.[7] In other words, no fundamental changes in the administration of maintenance resulted. In the reorganization of March 1942, however, the OCAC and the Air Force Combat Command, each with its own bases, were amalgamated and thus lost their separate identity, and the maintenance responsibility of the Commanding General, AAF, was

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6. Ibid., p. 77; "Annual Report, Materiel Division, 1940," pp. 1-2.
7. AR 95-5, 20 June 1941, pars 3b, 4f, and 5a.

thereafter administered alike at all continental bases by the Air Service Command, which had been established in October 1941 as the successor to the short-lived Maintenance Command. At the same time, the AAF was given maintenance responsibility for the equipment supplied to it by the Other Arms and Services but not maintained by those organizations.[8]

Headquarters of the Air Service Command, and of the other commands as well, were located in Washington during 1942 perhaps to keep their commanders in close contact with Headquarters, AAF during the days of greatest expansion. In December 1942, however, as a phase of a general move toward decentralization of responsibilities, Air Service Command Headquarters was moved to Patterson Field. Thereafter, liaison between the Air Service Command and the Commanding General, AAF was carried on by the Directorate of Base Services in Washington. In March 1943, the Directorate of Base Services became one part of the organization headed by the Assistant Chief of Air Staff for Materiel, Maintenance, and Distribution (AC/AS, M&D),[9] later, in July 1944, renamed Materiel and Services (M&S).[10] In the same manner as predecessor organizations, M&S received routine reports from the Air Technical Service Command and the other commands and air forces, passed down staff decisions relating to maintenance and supply, and coordinated technical directives.[11]

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8. AR 95-5, 15 June 1942, pars. 2, 3i, 3n, and 5d.
9. Organization of the Army Air Arm, pp. 37-45, 81-83.
10. Within the M&S office, formerly the M&D, staff supervision of maintenance was handled by the Air Services Division, and more specifically by the Supply and Maintenance Branch. This branch on 30 June 1945 consisted of 59 officers and 81 civilians.
11. Interview with Lt. Col. Clarence Haymes, Exec., Air Services Div., AC/AS, M&S, 24 July 1945. The diaries of the Air Services Division provide a day-to-day description of the staff work on maintenance policy accomplished by this organization.

Air Corps and GHQ Air Force Maintenance

One of the organizational features which served in some measure to complicate the administration of maintenance as late as 1941 was the division of the air arm into two coequal branches: the Office of the Chief of Air Corps and the GHQ Air Force (after June 1941 known as the Air Force Combat Command). A confusing factor was that "Air Corps" was also used as a collective term referring to both branches of the air arm. The OCAC operated the Materiel Division at Wright Field, the air depots, and various bases and installations carrying on technical and supply activities. Established 1 March 1935 as the striking arm, the GHQ Air Force included about 40 per cent of the personnel and an even larger proportion of the continental bases of the air arm. The commanding general of this branch had complete authority over tactical flying units and was responsible for their tactical training and maneuvers, and also for the performance of inspections and the lower echelons of maintenance. On the other hand, the GHQ Air Force was required to comply with the technical instructions pertaining to maintenance issued by OCAC through the Materiel Division. Further, the major overhaul of all flying equipment, whether belonging to the Air Corps or the GHQ Air Force, was performed by the air depots, which operated under the control of the OCAC.[12]

The actual work of maintenance inspections, repair, and also supply was accomplished at the GHQ Air Force bases by military organizations known as service squadrons and GHQ Air Force base troops. The service

12. Organization of the Army Air Arm, pp. 4-29.

squadrons, or combat units, were limited to personnel, equipment, and supplies sufficient for first echelon work. So far as maintenance was concerned, first echelon consisted of cleaning and servicing, the performance of 20- and 40-hour inspections, minor repair, and the replacement of unit assemblies. GHQ Air Force base troops did second echelon work; they were assigned the 80-hour inspections and made replacements and heavier repairs, including top overhaul (cylinder and valve repairs). Major overhaul, or what was known as third echelon maintenance prior to February 1942, had to be reserved for the depots.[13] In 1940, the GHQ Air Force created a new service organization, the Air Base Group, comprising a Base Headquarters and Air Base Squadron, a Materiel Squadron, and a number of units of Other Arms and Services. At the bases of the OCAC, similar maintenance and supply functions were performed by military organizations known as Air Base Squadrons.[14]

The Air Base Squadrons were taken over by the Maintenance Command, and later by the Air Service Command, to form the nuclei of the air depot and service groups, which were designed for combat operations overseas.[15]

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13. Materiel Memo 1, Hq., GHQ AF, 8 July 1936, in AAG 401 C, Systems of Supply and Maintenance.
14. ATSC historical monograph, "The Air Service Command: An Administrative History, 1921-1944," p. 25 [hereafter referred to as ASC Administrative History].
15. A detailed treatment of such military organizations and their training is to be found in ATSC historical monograph, "The Organization and Training of Tactical Service Units for Overseas Air Forces: Part I, 1935-1942," pp. 11-16. The individual technical training of enlisted mechanics is discussed in AAF Historical Studies: No. 26, Individual Training in Aircraft Maintenance in the AAF.

The Maintenance Command[16]

It has already been indicated that, below the level of AAF Headquarters in Washington, maintenance was administered by the Materiel Division, along with supply, research, and procurement. The Field Service Section of the Materiel Division was the agency immediately responsible for certain of these matters, and within the Field Service Section maintenance alone was handled by the Maintenance Branch. The primary functions of this branch consisted of studying maintenance procedures, initiating technical instructions, providing for the revision or recision of instructions already current, investigating failures of equipment, and processing Unsatisfactory Reports.[17]

The difficulties of administering uniformly Air Corps maintenance and supply in the two nearly independent branches of the air arm, the GHQ Air Force and the Air Corps, as well as the steadily increasing burden of work, prompted the Chief of the Materiel Division, Brig. Gen. Carl Spaatz, to recommend in October 1940 that a plan of reorganization be prepared for study. The first plan, submitted late in 1940 by the Field Service Section, envisaged "a supply and maintenance organization providing for the direct control and responsibility for these activities down to and including Air Bases and stations by the Chief of the Materiel

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16. A fairly complete account of the inception and development of the Maintenance Command is to be found in the ASC Administrative History, pp. 23-40.
17. In February 1940, the Maintenance Branch was made up of 7 units to which 36 civilians and 6 officers were assigned. Field Service Section Memo 41-23, 23 May 1941, in TSAGD 300.6, Memorandums.

Division."[18] The chain of command was to extend from the Field Service Section to the air depots, and from the depots it was to "fan out to the various air bases and stations within the control areas of the individual depots."[19] Heretofore, the Field Service Section could be said to have exercised only technical control of the maintenance and supply activities at the bases and stations, but direct command control over the four air depots. The new plan proposed that the command jurisdiction of the Materiel Division (through the Field Service Section) be extended to cover maintenance and supply facilities and personnel at the Air Corps stations, and it further provided that the Corps Area Headquarters be eliminated as an administrative link in the Air Corps supply scheme. (The Corps Area had never figured importantly in the Air Corps maintenance system.) A second plan submitted a week later added the suggestion that Other Arms and Services officers be assigned to the Field Service Section for the purpose of supervising and coordinating activities pertaining to materiel procured by their respective services for the Air Corps.[20]

The basic features of these plans were worked into a proposal for the Air Corps Maintenance Command which came under consideration during the winter of 1940-1941. The plan for the Maintenance Command, particularly the provision for centralized control of maintenance and supply at both Air Corps and GHQ Air Force bases, did not pass without a demurrer. Lt. Gen. Delos C. Emmons, the Commanding General of the GHQ Air Force,

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18. Memo Report FM-40, 22 Nov. 1940, in ASC Administrative History, App. B.
19. Ibid.
20. Memo Report FM-41, 28 Nov. 1940, in ASC Administrative History, App. B.

wrote:[21]

> The proposed Maintenance Command would operate by taking over GHQ Air Force air base functions of supply and maintenance at the expense of tactical mobility and effectiveness . . . . My recommendations are as follows: That a Maintenance Command be organized under a general officer and separated from the other parts of the present Materiel Division. That, except for technical supervision, responsibilities for supply and maintenance stop at the boundary of the air base.

In stating such objections, General Emmons gave voice to the conflict more or less traditional in the Army between two concepts of command: the concept of unified control of all activities at a given base or installation versus the concept of parallel chains of command, one for tactical operations, and one for services--supply and maintenance.[22]

The decision was in favor of the theory of parallel chains of command,[23] and the Provisional Air Corps Maintenance Command was adopted 15 March 1941. Having been accorded War Department approval, it was renamed the Maintenance Command on 29 April 1941.[24] Upon activation, the new command comprised a Headquarters at Patterson Field, the Field Service Section, the four continental air depots, and the 50th Transport Wing. In addition, the Fairfield and San Antonio Group Areas, each consisting of several installations known as subdepots, were established as subordinate units of the new command. Attendant upon the expansion of the

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21. Lt. Gen. Delos C. Emmons, CG, GHQ AF, to C/AC, 27 Jan. 1941, in AAG 321.9, Maintenance Command.
22. See "Papers on Organizational Relationships between Army Air Forces and Army Service Forces," revised 11 Dec. 1944, in AFSHO files.
23. Resort to the "parallel chains of command" system was justified on the basis of the experience of the RAF. It was pointed out that under this plan combat units were relieved from duties and responsibilities relating to supply and maintenance and that they were therefore able to devote all their energies to tactical operations. Memo Report FM-40, 22 Nov. 1940.
24. TAG to CG, GHQ AF, etc., 29 April 1941, in AG 320.2, Air Corps (4-25-41) M (Ret) M.

air arm in 1939 and later, the great need for many subdepot installations for maintenance and supply functions was recognized.[25] This realization, together with the fact that a large control agency had to be provided for such installations, was an important consideration underlying the conception of the Maintenance Command.

The stated purpose of the Maintenance Command was to keep the largest proportion of airplanes possible in flying condition through the efficient administration of maintenance and supply.[26] This mission it sought to carry out, as indicated above, by taking over the two highest echelons of maintenance and supply, then known as second and third echelon.[27] There was no difficulty about third echelon, or depot maintenance, inasmuch as the depots, operating under the Field Service Section, continued to perform this work for all flying organizations just as before. Second echelon, however, was taken over from military units at the Air Corps bases which had hitherto accepted this responsibility, and assigned to the newly created subdepots, where facilities were available. In deference to such objections as those raised by General Emmons in the letter quoted above, it was at first decided not to establish subdepots at GHQ Air Force bases, and second echelon work at such bases continued to be the responsibility of the tactical organizations until January 1942.[28]

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25. A systematic account of the development of the subdepots is reserved for Chapter III of this study.
26. Lt. Col. Clements McMullen, CO, SAAD to CO, Randolph Fld, 25 March 1941, in TSCHI-2 files.
27. TO 00-25-4, 13 Nov. 1940. In 1942 and later, depot maintenance was called fourth echelon, and certain lighter repair procedures assigned to subdepots were called third echelon. See TO 00-25-4, 14 Feb. 1942; also Chap. IV of this study.
28. 1st ind. (Capt. H. D. Baggerley, Supply Officer, Manchester Air Base, Manchester, N. H., to Asst. Chief, Mat. Div., 21 April 1941), Chief, Maint. Comd to CO, Manchester Air Base, 25 June 1941, in TSAGD 323.61, Organization ASC.

The brief existence of the Maintenance Command (it was absorbed by the Air Service Command 17 October 1941) did not permit the working of miracles. In fact, the Field Service Section as the principal headquarters component continued under the Maintenance Command just as under the direct supervision of the Chief of the Materiel Division, except that a few subdepots now had to be taken into account. The principal advantage of the Maintenance Command over the older organization was that it provided a larger framework for the expansion of the administrative units. Further, the great importance of maintenance and supply was recognized in the creation of a special command for the supervision of these functions.

Maintenance Under the Air Service Command and the Air Technical Service Command

The fact that the Maintenance Command was succeeded 17 October 1941 by the Air Service Command did not in itself affect the administration of maintenance. The Field Service Section was taken over intact and it continued to function relatively undisturbed until the outbreak of war on 7 December 1941, after which it underwent great expansion and many changes, including a change of its title to Air Force Section.[29] It was finally dissolved in December 1942, whereupon its units, according to their functions, were assigned to the newly created (1) Maintenance, (2) Supply, and (3) Personnel and Training Divisions. The establishment of these three divisions was part of the general functional reorganization

29. GO 26, Hq., ASC, 26 March 1942.

of the Air Service Command. The functional or straight-line organization proved to have certain advantages over the conventional command organization. Headquarters of the Air Service Command had heretofore tended to act as a bottleneck because lower echelons, having little authority, were obliged to refer many decisions to the general staff and the commanding general. The new organization eliminated the general staff and gave broad authority to the division chiefs. Thus, the newly created Maintenance Division[30] could normally act on maintenance problems much more expeditiously. This general organization remained in effect for the duration of the war, although there were certain internal changes.

The most significant of these changes resulted from the assumption of maintenance responsibility for equipment originally furnished to the Air Forces by the Other Arms and Services. The Signal Corps, the Ordnance Department, and the Quartermaster Corps in particular supplied essential materiel to the air arm, and, prior to late 1943, retained a considerable measure of responsibility for its maintenance. The procedures involved in the supply and maintenance of such classes of property proved to be cumbersome under the stress of wartime conditions. There were even occasions on which the equipping of combat aircraft was seriously impeded by the delays inherent in the old system.[31] The first step toward correcting the situation was taken shortly after the declaration of war

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30. In January 1943, the newly organized Maintenance Division consisted of a section each for aircraft, engines, accessories, associated equipment, miscellaneous equipment, and maintenance control. The Aircraft and Engine Sections were broken down into branches for specific types and makes of equipment; and within the branches, special units processed UR's, prepared Technical Orders, analyzed accidents, prescribed overhaul procedures, etc.
31. For a discussion of the defects of the old system of supply and maintenance so far as Signal Corps equipment was concerned, see ASC Signal Corps Activities, pp. 12-33.

when a Special Staff Section for each of the Other Arms and Services was set up in Headquarters, Air Service Command (ASC). In these sections, which operated under the Commanding General, ASC, control of the supply and maintenance of the equipment needed by the AAF was centralized. The vast quantities of airborne and ground radio and radar equipment provided by the Signal Corps was of especially great importance to the air war, and the Signal Section came to be the largest of the Special Staff organizations. Its responsibilities included supervision of the unit training of AAF personnel in radio supply and maintenance and the training of civilian radio mechanics for the air depots. The Ordnance Section assumed responsibility for the maintenance of AAF automotive vehicles as well as for the supply and maintenance of gunnery equipment. Direct AAF control of functions formerly performed by the Other Arms and Services greatly improved the supply and maintenance of signal equipment, special purpose vehicles, and other property procured for AAF use. The assimilation of such functions by the AAF continued. The Special Staff Sections within the Air Service Command continued in existence until 1 November 1943 when they were absorbed by the three operating divisions—the (1) Supply, (2) Maintenance, and (3) Personnel and Training Divisions—of that command (see Figure 2).[32]

After the Maintenance Division had absorbed the maintenance branches of the Special Staff Sections, its personnel consisted of approximately

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32. For a discussion of the part played in the AAF program by all the Other Arms and Services, see draft AAF Historical Study, "Relationships between the AAF and the War Department and Other Agencies."

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CHRONOLOGICAL MAP

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1,700 persons, of whom one-fourth were military personnel.[33] During 1944 several significant additions were made to the functions of the division: (1) there was initiated a program of integration of all maintenance activities whereby facilities at each AAF base were consolidated for economy of operation;[34] (2) responsibility for fourth echelon maintenance and repair of all vehicles and motorized equipment used by AAF was assumed;[35] (3) responsibility was also assumed by the Air Service Command for the maintenance and repair of fixed communications equipment and for the operation of certain Signal Corps installations—that is, the process of absorbing into the Air Service Command the functions of the Other Arms and Services that pertained to the Army Air Forces was continued;[36] (4) finally, the ASC was directed to provide for the planning, equipping, and maintenance of marine equipment used by the AAF, such as the floating repair units.[37]

The creation of the Air Technical Service Command on 1 September 1944[38] brought about no fundamental changes within the Maintenance Division although the facilities and personnel of the former Materiel Command printing plant were absorbed. As of 31 December 1944, the Maintenance Division was staffed with a total of 2,051 persons[39] and by

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33. Figures as of 1 Jan. 1944, "Maintenance Division Annual Report, 1944," p. 7, in TSCHI-2 files.
34. AAF Reg. 65-73, 22 Jan. 1944. That is, base engineering shops were consolidated with Maintenance Division activities where there was duplication.
35. AAF Reg. 65-8, 4 Oct. 1944.
36. ASC Signal Corps Activities, 30-33.
37. See ATSC historical monograph "A History of the Army Aircraft Repair Ship Project, November 1943-September 1944."
38. ATSC Reg. 20-33, 1 Sep. 1944.
39. "Maintenance Division Annual Report, 1944," p. 7.

30 June 1945, with V-J Day two months away, total strength had dropped slightly because of the lessened urgency of the war situation.[40] In July 1945, the Maintenance Division, along with the Engineering Division, was placed under the supervision of the Deputy Commanding General, Engineering (T-3), but again its functions were not altered.[41]

The exigencies of war had the effect of enlarging very considerably the list of responsibilities assumed by the Chief of the Maintenance Division. His primary mission, of course, was to insure that the largest possible number of Army aircraft were kept in flying condition. This basic function soon came to be reinforced by many specific provisions. In a directive of 1945, for example, it was stipulated that the Chief of the Maintenance Division, who was under the jurisdiction of the Chief of Supply and Maintenance, be charged with the maintenance of complete aircraft, aircraft components, engines, accessories, associated equipment, communications systems, and also of other equipment (principally, vehicles and marine equipment) required by the AAF for the fulfillment of its mission. In the same directive, maintenance was defined to embrace quality control (that is, special measures to insure that repaired items met certain standards), periodic inspection, servicing, preventive maintenance (corrosion control, tropicalization, winterization, shipping protection, storage protection, etc.), overhaul, reclamation, repair, restoration, and the preparation and publication of necessary instructions pertaining to these activities.[42]

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40. "Monthly Report of ATSC Civilian and Military Personnel, 30 June 1945," Product No. SU-P-368.
41. ATSC Reg. 20-1, 5 July 1945.
42. ATSC Reg. 65-23, 1 June 1945.

The discharge of these multiple tasks involved the supervision of all maintenance activities at the depots. The four depots in operation in 1939 had increased by 1944 to 12, and further, the productive capacity of each of the original depots had been greatly expanded.[43] Prior to 1 January 1944, the third echelon work performed by the 200-odd subdepots was also controlled by the Air Service Command through the area commands.[44] The supervisory work of the Maintenance Division consisted essentially of establishing policies and procedures for fourth echelon work and scheduling it at the depots; furnishing technical assistance to the air forces, commands, and theater air service commands on maintenance matters; providing all activities of the AAF with technical publications; and, in coordination with the Engineering Division, processing Unsatisfactory Reports submitted on all technical equipment.[45] The manner in which the Maintenance Division carried out its tasks is reflected in the discussion of depot operations.[46]

Maintenance Organizations at the Depots

During the time the far-reaching changes described above were being effected, the depots continued to perform the overhaul of aeronautical equipment as they had been doing for approximately 20 years. This is not to suggest that maintenance activities at the depots did not undergo changes themselves. At the beginning of 1939 the maintenance personnel

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43. For an account of the development of the depots, see ATSC historical monograph, "History of the Acquisition of Facilities for the Air Service Command."
44. Chap. III of this study deals with the subdepots.
45. ATSC Reg. 20-23, 1 June 1943.
46. See Chap. VI of this study.

at the four continental depots totaled fewer than 1,800 persons. For this relatively small number of employees, a simple organizational structure sufficed.[47]

The survey of the air depots in 1939 revealed that there were insufficient facilities even for the few air force units then in being. Furthermore, much shop equipment was found to be obsolete, and the general layout of all but one of the depots[48] was considered ill adapted to the handling of large, modern aircraft. Although the beginning of procurement under the 5,500-airplane program enacted 3 April 1939 rendered existing facilities even more inadequate, the expansion of the four continental depots did not get well under way until late in 1940. By that time, the increased tempo of the war in Europe and the adoption of the 54-group program made apparent the necessity for additional air depots. Sites were selected, construction was begun, and each of the new installations was pressed into service as it neared completion. Of the eight new depots, seven came into production during 1942 and 1943, and the last, Miami, performed its first major overhaul early in 1944.[49]

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47. The depot engineering departments consisted of executive, drafting, and shop sections, the last-named section broken down into seven departments. The most important of these performed aero repair and engine repair. See "The Maintenance of Army Aircraft in the United States: Part I: 1921-1939," pp. 58-59.
48. Sacramento was the most modern of the depots in 1939. When North Island, the site of the old Rockwell Air Depot, was turned over to the Navy, depot equipment and personnel were moved to Sacramento, where new buildings were constructed. The move took place during 1938-1939, and the first airplane overhaul to be accomplished on the new site was completed in June 1939. "History of the Sacramento Air Service Command," pp. 291 ff.
49. A detailed account of the construction of depot facilities is to be found in ATSC historical monograph, "History of the Acquisition of Facilities for the Air Service Command," pp. 14-32. For an account of deficiencies in supply facilities, see ATSC historical monograph "The Evolution of the Storage System of the Air Technical Service Command, Part I: 1918-1940," pp. 146-48.

Engineering personnel at the old depots increased while the new installations were beginning large-scale operations until by late 1943 they totaled in all depots well over 65,000.[50] Moreover, the organization of the depot engineering activities steadily became more elaborate as units were set up to handle highly specialized jobs.[51]

To follow through all the various stages in the organizational development of the depots is unnecessary here, but the most important of the changes in the engineering or maintenance organization should be noted. After the reorganization of the Air Service Command in December 1942, the depots were directed to alter their organizations accordingly. Thus, the engineering activities at each depot came to be known as the Maintenance Division. Within the depot Maintenance Division were subdivisions, of which the Aircraft Shop and Equipment Section included all the overhaul and repair activities.[52] The aircraft shops in the organization included six sections with units specializing in sheet metal, wheels and brakes, carburetors, and the like.[53] With the integration of maintenance activities, still other sections were added until the standard organization of the depot Maintenance Division in May 1945 was as represented on the chart (see Figure 3).[54]

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50. Personnel figures by depot and year are given in Chap. VI.
51. In 1940, the depot aircraft shops included branches for aero repair, engine repair, electrical equipment and accessories, and metal manufacturing and repair. In turn, these branches were subdivided according to function, such as dismantling and cleaning.
52. ASC Manual 20-1, 15 March 1943.
53. ASC Reg. 20-1Y, 20 Jan. 1944.
54. ATSC Reg. 21-30, 3 May 1945. Intervening changes are indicated on charts attached to ASC Reg. 20-1R, 25 Aug. 1944, and ATSC Reg. 21-30, 4 Jan. 1945.

ORGANIZATION OF THE MAINTENANCE DIVISION, AREA AIR TECHNICAL SERVICE COMMAND

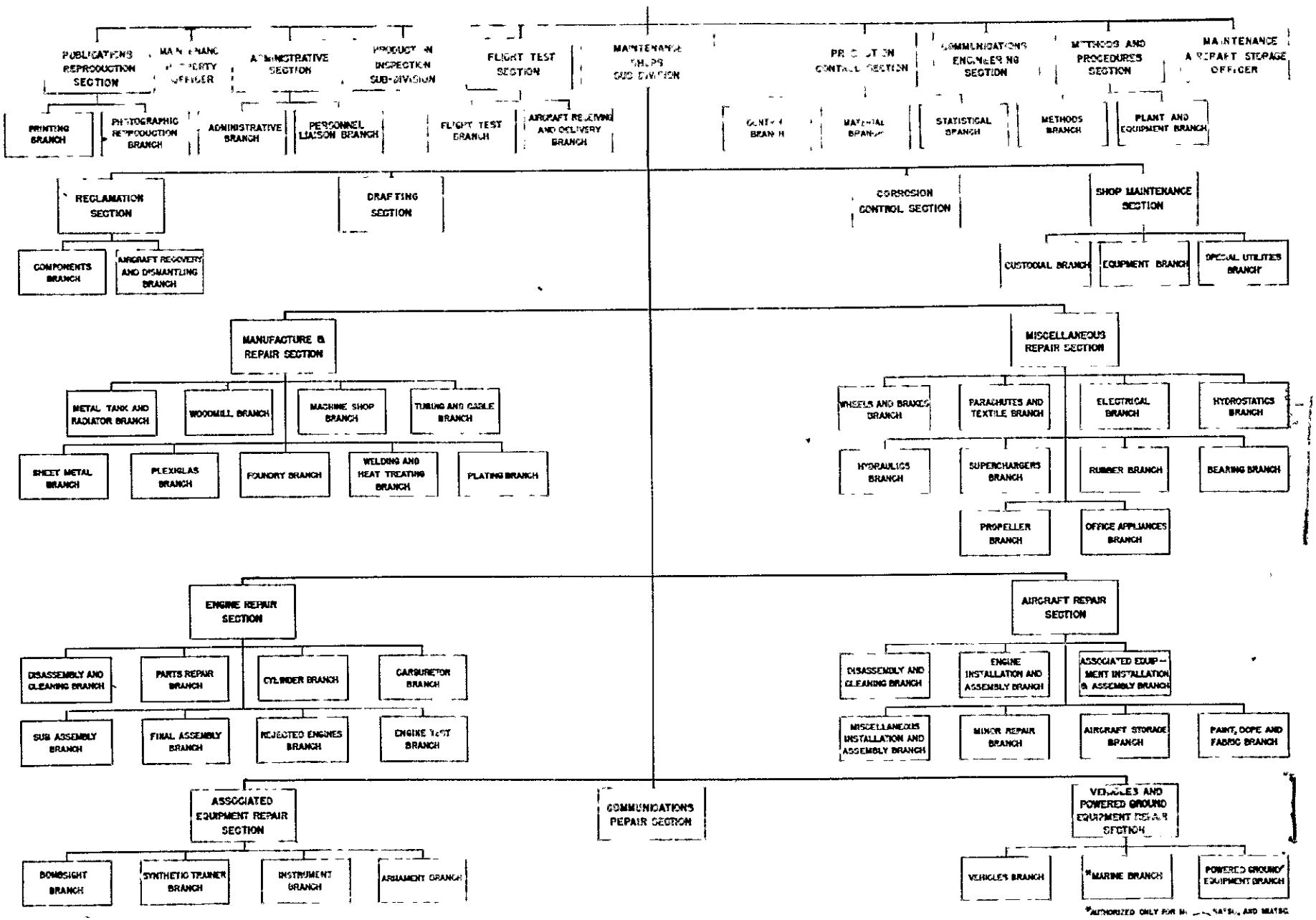

FIGURE 3

Commercial Overhaul Activities and Air Depot Detachments

Operating under the supervision of the air depots were various commercial overhaul activities. The policy traditional in the Air Corps was to perform all maintenance and overhaul work at Air Corps installations.[55] To some extent, however, conditions forced a modification of this policy during the war. In 1939, connections with commercial enterprises began with the decision to carry on Air Corps flying training at certain civilian flying schools by way of supplementing the regular training facilities. Six of these schools were functioning in 1940, and the number increased steadily, some of them being started under Lend-Lease arrangements for the training of British pilots. Inasmuch as the schools were made responsible for the overhaul of the equipment they used, they normally contracted for this work with commercial concerns.[56]

This arrangement was allowed to stand until February 1942 when Headquarters, ASC directed the various air depots to assume responsibility for the proper performance of supply and routine inspections at the flying schools for British pilots. This responsibility was later extended to cover all other civilian flying and glider schools and the overhaul agencies under contract to them.[57] The Air Service Command also took over the contracts for overhaul and authorized the depots to

55. "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," p. 62.
56. Interview with J. F. Brown, Aircraft Maint. Supervisor, Contract Serv. Br., Maint. Control Sec., Maint. Div., ATSC, 19 Sep. 1945.
57. Instructions with respect to the British flying schools were sent to San Antonio in the form of a radiogram from Headquarters, ASC on 11 February 1942, and later directions applying to the other schools were issued 6 June 1942. See "History of the San Antonio Air Service Command to February 1943," pp. 37-38.

find more commercial sources for repair. Additional facilities for the reconditioning of primary trainers, such as the PT-13's, PT-17's, PT-19's and PT-23's, and their Continental, Lycoming, and Ranger engines were necessary because of the steady increase of training activities and also the need to reserve the air depot and subdepot facilities for the more complex job of repairing and modifying combat airplanes. In all, contracts were let to 22 different concerns, of which 6 reconditioned airplanes, 8 overhauled engines, 1 repaired wooden propellers, and the remainder overhauled both airplanes and engines. The Air Service Command through the depots also supervised the fourth echelon work performed for the AAF by other commercial contractors--namely, the airlines taken over by the Air Transport Command. Nineteen airlines and approximately 1,500 airplanes, most of them transports, were involved. The shops of 17 of the airlines were actively engaged in overhauling this equipment during the war.[58]

In order to carry out its obligation to supervise maintenance at the civilian flying and glider schools, the contract overhaul agencies, and the airline shops, the air depots provided small, appropriately trained units which came to be known as Air Depot Detachments. These units, consisting of from four to seven civilian maintenance and supply people and an officer, were stationed at the various commercial activities, although they were considered part of the air depot staff.[59] In addition, AAF inspectors visited the installations to check on the

58. Interview with J. F. Brown, 19 Sep. 1945.
59. The composition and duties of the Air Depot Detachments are set forth in Depot Control Area Memo 80-10, Hq., SAAD, 2 Sep. 1942, in "History of the San Antonio ASC to February 1943," App. 15.

quality of their work. So far as contract overhaul was concerned, this arrangement continued from 1942 to 1944, when the reduction of training rendered such supplemental facilities unnecessary. The termination date for the contract agencies was 30 June 1944, but backlogs of work kept some of them occupied until September of that year.[60] In general, these agencies performed an essential service very well, and their large contribution to the training program was officially recognized.[61] The airlines shops continued to overhaul Air Transport Command equipment from 1942 through the course of the entire war, and even for a short time thereafter were operating on a curtailed basis.[62]

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60. Interview with J. F. Brown, 19 Sep. 1945; Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC to CG, FASC, 11 March 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.
61. See letters of commendation to each of the contract overhaul agencies in files, Contract Serv. Br., Maint. Control Sec., Maint. Div., ATSC. It is stated in other correspondence that UR's were submitted on less than 2 per cent of the equipment repaired by such agencies, and that the quality of work and economy of operations were, in general, excellent.
62. Interview with J. F. Brown, 19 Sep. 1945. Production figures for contract overhaul and airline shops are given as accurately as possible in Chap. VI. The depot reports did not include the work of these agencies.

Chapter III

SUBDEPOT CONTROL[1]

Activation of the Subdepots

The air depot facilities were designed to provide only for the highest echelons of maintenance and supply. But, as the AAF expanded, facilities at the air bases--hangars, runways, shops, and warehouses--had to be enlarged and equipped so that the lower echelons of service could also be performed. Further, many new air bases had to be constructed. Like the need for more and larger depots, the future requirements for additional air base facilities were anticipated at a fairly early date. As a matter of fact, the Provisional Maintenance Command, as has been shown, was established for the purpose of providing centralized control of the maintenance and supply facilities at the air bases and to superintend the extension of these installations. Such base facilities were called subdepots, apparently the first use of the term, in a directive of February 1941 prescribing the organization of the Provisional Maintenance Command.[2] Upon the activation of the Provisional Air Corps Maintenance Command on 15 March 1941, subdepots were to be established at 10 Air Corps bases, of which the first four

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1. The present account of subdepots deals principally with the administrative history and the maintenance activities of these installations. For an account of subdepot supply, see ATSC historical monograph, "The Evolution of the Storage System of the ATSC," Part II.
2. Maj. Gen. George H. Brett, Asst. C/AC to CG, GHQAF, etc., 14 Feb. 1941, in TSCHI-2 files.

were in the so-called Fairfield Provisional Maintenance Group Area, and the remainder in the San Antonio Area.[3]

Preliminary instructions provided, first, that the Materiel Section (that is, the engineering and supply departments) at the several stations would thereafter be known as the Maxwell Field Subdepot, Randolph Field Subdepot, etc., but that the official names and functions of the other activities on the base would not be affected; second, that a subdepot commander, who might also be engineering or supply officer, would assume responsibility for engineering and supply property and command control of the military personnel assigned to those activities; third, that the normal function of the subdepot would be the performance of second echelon maintenance[4] of Air Corps equipment on the post and of the procurement, storage, and issue of all types of Air Corps supplies, including fuel and oil.[5]

Later it was stipulated that the subdepots would operate under the supervision of the control depots to which assigned, and that the control depots in turn would be subject to the maintenance wing commanders,[6] the immediate subordinates of the Commanding General, Maintenance Command. Enlisted men assigned to the subdepots would be released as soon as

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3. The 10 bases were as follows: Selma, Ala.; Montgomery Airport; Maxwell Field; Eglin Field; Barksdale Field; Randolph Field; Kelly Field; Brooks Field; San Angelo; and Ellington Field. Ibid.
4. The term "third echelon maintenance" was not regularly used to describe the operations allotted to the subdepots until after the publication of TO 00-25-4, 14 Feb. 1942.
5. Memo by Lt. Col. Clements McMullen, CO, SAAD, 25 March 1941, in TSCHI-2 files.
6. The Maintenance Wings of the Maintenance Command were never activated except in the form of the Air Service Area Commands, in December 1941. See ASC Administrative History, pp. 56-58.

adequate civilian replacements could be secured. The subdepots, in fact, were to be civilian-operated except for the supervision of commissioned officers. The functions of the subdepot commander were not to interfere with the prerogatives of the station commander. That is, subdepot personnel were to remain under the disciplinary control of the station commander, but the latter was not to hamper the work of the subdepot by assigning post duties to such personnel. Further, the post commander was to furnish transportation, fire protection, and guards to the subdepot.[7]

It was also directed that, as soon as practicable, the Commanding General, Air Corps Maintenance Command would install subdepots at all stations under the direct control of the Chief of the Air Corps.[8] Accordingly, others were added very soon. The Fairfield and San Antonio Air Depots superintended these early activations. At Fairfield, the Chief of the Subdepot Section undertook the task of organizing the subdepots with the assistance of a number of civilians. An experienced civilian was sent to Maxwell Field on 1 April 1941, with a cadre of civilians trained in maintenance and supply at the Fairfield Depot. With the cooperation of officers at the air base, more civilians were hired locally and on-the-job training was then instituted. In time, the military units that had been performing such work were released for other duties. After operations at Maxwell Field were well under way, the civilian administration proceeded to three other fields where, with

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7. Maj. Gen. George H. Brett, OCAC, to CG's of the Southeast, Gulf Coast, and West Coast Training Centers, etc., 28 Aug. 1941, in AAG 321.9, Maintenance Command.
8. Ibid.

new cadres from Fairfield, he repeated the organizational process.[9] In the meantime, the same work had been going on at bases in the San Antonio Area, and elsewhere in the Fairfield Area.

As more and more activations were ordered, it came to be customary for cadres to be trained not only at the depots, but also at the subdepots already in operation. Thus, an administrator from the San Antonio Air Depot, having activated the Lake Charles and Stuttgart Subdepots in January 1942 with a cadre of 25 people from the San Antonio Air Depot, arranged for training three complete cadres at these bases and with them activated more subdepots without drawing additional personnel from the San Antonio depot.[10] Shortly after the outbreak of war, it was decided that subdepots would also be needed at the Air Force Combat Command stations to provide properly for the maintenance of tactical organizations; then the maintenance and supply system of the air arm could at last be said to be centralized.[11]

For guidance in handling the many activations new instructions were issued in January 1942. Subdepots were authorized at all bases where no less than one group of aircraft[12] was stationed. This provision was later defined more exactly: Class I subdepots were to be set up where aircraft totaling more than 150 engines were based, and Class II

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9. "History of the Air Depot at Fairfield, Ohio, 1917-1943," pp. 119-21.
10. Interview with A. J. Nassamer, Superintendent, Aircraft Repair Sec., Maint. Div., FATSC, 10 July 1945.
11. The Air Service Command was directed to proceed with the activation of subdepots at certain Air Force Combat Command bases as early as 2 Jan. 1942. Lt. Col. L. P. Whitten, Exec., ASC to Asst. Chief, ASC, 2 Jan. 1942, in AAG 323.7J, Depots and Subdepots.
12. The number of aircraft making up one group varied with the type of airplane. For example, there were 68 heavy bombardment airplanes in a group, but a pursuit group consisted of 130 airplanes.

subdepots where the number of engines totaled less than 150.[13] The personnel problem was also dealt with fully in these instructions. The officers, enlisted men, and civilians needed to operate the engineering and supply departments of the base as of 1 January 1942 were to be taken as the normal personnel requirements of the subdepot unless there had since been an increase or decrease in flying activities. All enlisted men were to be released not later than July 1942, 50 per cent of them to be returned to the base commander, and the remainder made available to the Air Service Command for assignment to air depot groups. It was expected that sufficient civilian workers would have been trained to do the subdepot maintenance and supply before the enlisted men were released. Finally, all concerned were reminded that the sole purpose of the subdepot was to serve flying organizations and that therefore complete cooperation between subdepot and base commanders was essential.[14]

As of 8 December 1941, 47 subdepots were in operation, but activations after that date occurred much more rapidly. By 3 September 1942, when number designations were assigned the subdepots, 130 were functioning or were in the process of activation.[15] Instead of being concentrated in the Fairfield and San Antonio Areas like the first installations, subdepots began to appear on airfields in all sections of the country. The wide distribution in April 1942 is shown on the map (see Figure 4). During 1943, there was more than an 80 per cent increase, and on 1 January 1944, when it was determined that control should no longer be exercised

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13. AAF Reg. 65-6, 7 Feb. 1942.
14. Col. William M. Dick, Air Adj. Gen., to CG, Combat Comd, etc., 24 Jan. 1942, in TSCHI-2 files.
15. TAG to CG, ASC, 3 Sep. 1942, AG 320.2 (9-2-42) MR-M-AF, in TSCHI-2 files.

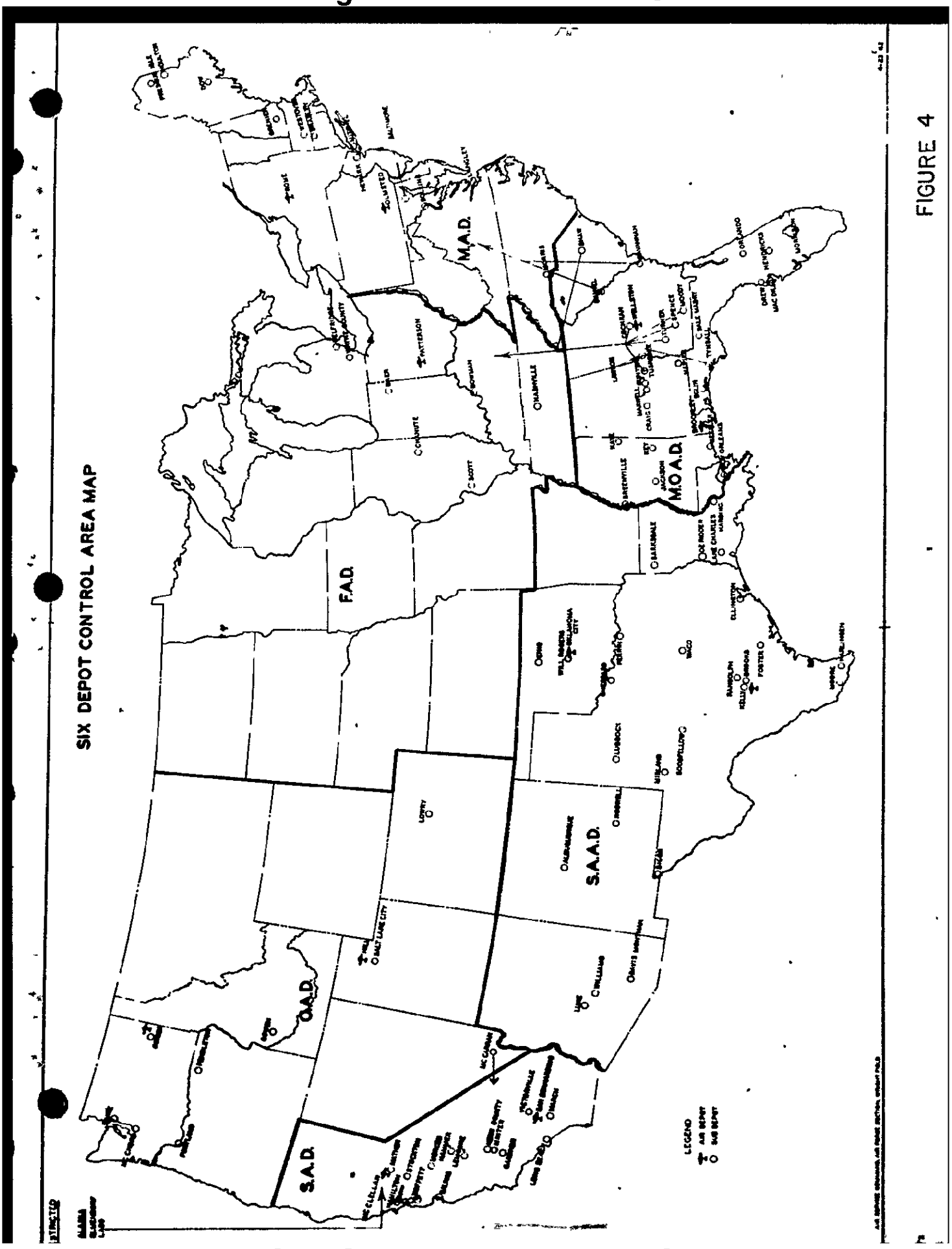

FIGURE 4

by the Air Service Command, 238 subdepots, of which 216 were active, were transferred to the other commands and the continental air forces.[16]

The earlier subdepots were generally established at flying bases already in full operation. Later, however, many were installed on new bases even before flying was begun by the using organizations. When the Subdepot Section of one of the control depots learned of the construction of a new base in its area, it made plans for a subdepot of appropriate size. A parent subdepot was named and given notice to train a cadre of workers for the new installation. Also, requisitions for equipment were processed through Air Service Command channels.[17] In general, these preparations greatly facilitated the establishment of subdepots. Because a number of subdepots were developed on the basis of the shops and equipment already existing on the older field whereas the remainder were entirely of new construction, a wide variety of types and quality of maintenance and supply facilities resulted. A typical subdepot, however, might be said to consist essentially of the following: a maintenance inspection hangar; engine cleaning building; warehouses; oil, paint, and dope building; reclamation shed and yard; and a shop providing space for sheet metal, wood working, electrical, and paint departments.[18]

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16. A list of the subdepots with approximate activation dates and other information is incorporated in the App.
17. Col. T. W. Scott, Chief, Subdepot Control Sec., SAAD to CG, Fld. Servs., ASC, 7 Oct. 1942, in TSAGD 323.3, Organization--Subdepots.
18. AT3C historical monograph, "History of the Acquisition of Facilities for the Air Service Command," pp. 113-14.

Subdepot Operations

The control of the subdepots was assigned to the various continental air depots. Although Fairfield and San Antonio activated the earliest of them, Middletown and Sacramento began cooperating in the program by the end of 1941. As new air depots came into operation, they were normally given charge of those subdepots in their areas which had been activated by one of the older depots. Some subdepots were even shifted to a third control agency as the number of depots increased. Such changes in administration tended to work hardships because accustomed lines of supply and other services were broken. There were isolated instances, however, where, even after transfer to a different control depot, subdepots continued to transact business with their original source of supply. Certain Mobile, Ala. subdepots, after they had been allotted to Warner Robins, continued by tacit agreement to draw upon Mobile for parts and supplies for tactical aircraft while subdepots in both the Mobile and Warner Robins Areas depended upon Warner Robins for trainer airplane parts. This arrangement was considered undesirable and was terminated 15 August 1943.[19]

The control agency within the depot organization, usually known as the Subdepot Section,[20] was made responsible for technical inspections

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19. Brig. Gen. James A. Mollison, CG, MOADCAC to Brig. Gen. L. T. Miller, Chief Supply Div., ASC, 12 July 1943, in TSAGD 401, System of Supply. Also, T.X, ASCSP2-7-39, CG, ASC to CG, MOASC, 14 July 1943, in ibid.
20. "History of the Air Depot at Fairfield, Ohio, 1917-1943," pp. 122-23. The Subdepot Section consisted of a chief, several assistants, the depot engineering and supply officers, and a clerical force. At Fairfield, 10 officers and 100 civilians were assigned to this section by 1943.

of the subdepot facilities and operations, for the proper handling of reparable equipment sent in by the subdepots for overhaul, and for the flow of supplies from the depot. Frequently, modification jobs were assigned to the subdepots. At the direction of Fairfield, for example, the 5th Subdepot, Baer Field, Ind., undertook a gun-mount and door modification of 165 B-26C airplanes beginning in February 1943.[21]

The subdepots were organized somewhat along the lines of the depots. The approved engineering department organization as of June 1942 shows 21 different sections, although not all of these were needed at the smaller installations. The Air Service Command reorganization of December 1942, already mentioned, which created the Maintenance, Supply, and Personnel and Training Divisions, was to be carried down through the depots and even into the subdepots. Nevertheless, the engineering organization within the subdepot continued to be known as a department rather than a division until late in 1943 (see Figure 5). In the 208 civilianized subdepots[22] in operation 31 December 1943, the number of employees in all activities ranged from fewer than 100 at some minor installations to 800 and more at the 8th Subdepot, Barksdale Field, and other large bases. The average number of civilians in the maintenance departments alone as of the end of 1943 was approximately 255.[23] In addition, several officers were assigned to each subdepot in supervisory capacities.

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21. "History of the Fairfield Air Service Command, 1943-1944," p. 13.
22. Certain subdepots were necessarily manned with military personnel, as will be explained presently.
23. "Monthly Report of Distribution of Civilian Personnel as of 31 Dec. 1943," in Personnel Statistics Sec. files, Hq., ATSC. Over-all figures for subdepot personnel are given in Chap. VI.

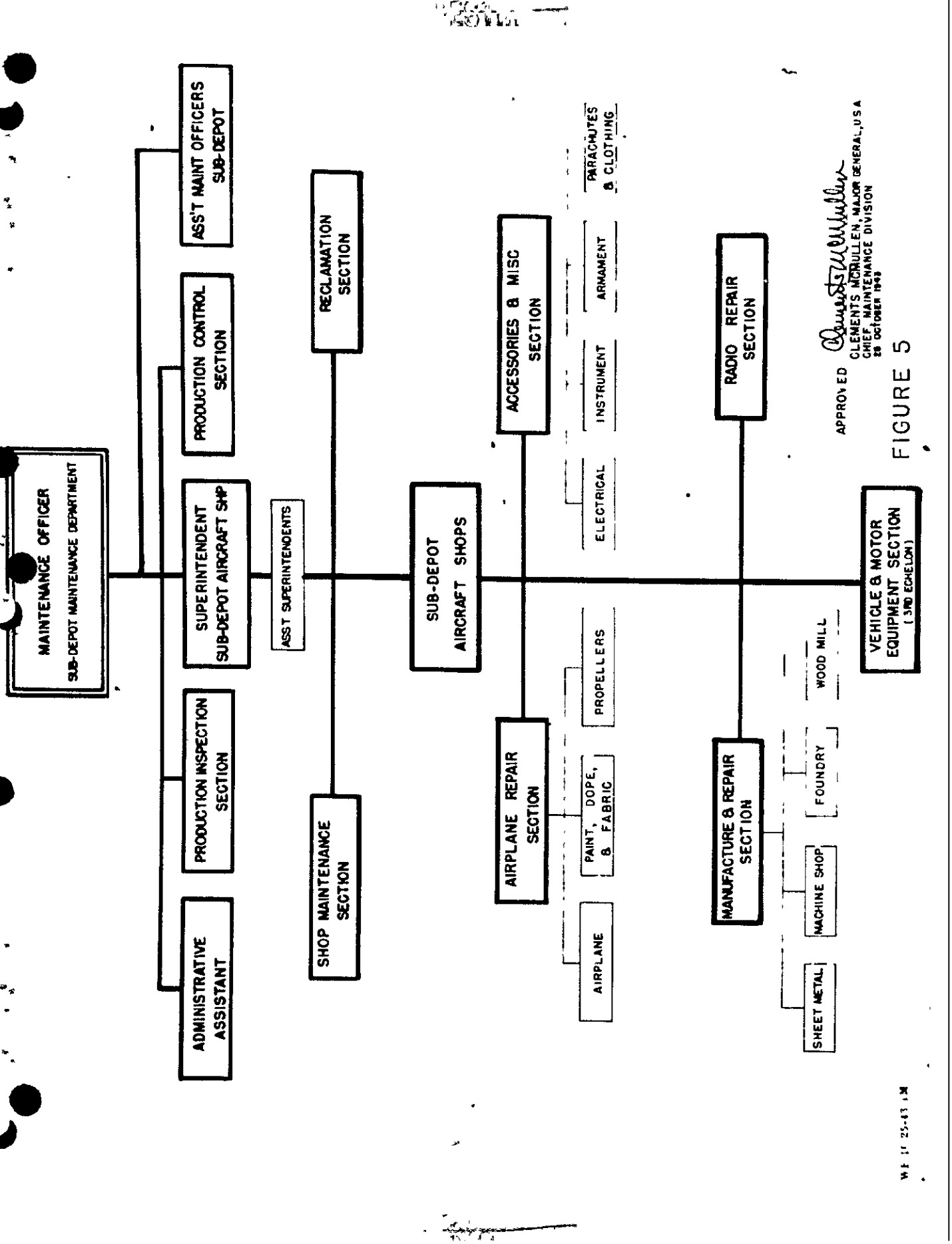

FIGURE 5

Units of all flying organizations were serviced by subdepots within the United States. Nearly 40 per cent of the subdepots were on Training Command bases and a slightly higher proportion on the bases of the continental air forces.[24] At a typical Training Command station, such as Lynn Field, Bainbridge, Ga., where the 6th Subdepot was located, there were from 225 to 260 airplanes, most of them basic trainers, BT-13A's and BT-15's. The subdepot personnel needed to service these airplanes consisted on 31 December 1943 of 8 officers and 339 civilians, of whom approximately 225 were assigned to maintenance. During December 1943, 175 airplanes were inspected, repaired, and returned to service by the 6th Subdepot.[25] At a representative tactical base, March Field, Calif., belonging to the Fourth Air Force, there were 286 airplanes as of 31 December 1943, most of them P-38's and B-24's. The 64th Subdepot, located at March Field, was staffed by 9 officers and 805 civilian employees, and of the latter, 418 performed the maintenance work for the 286 airplanes.[26]

The subdepots were charged with the performance of all third echelon maintenance within their capabilities and such second echelon work as was directed by their commanders. In January 1943, Class III subdepots, to be set up at "special" bases like Gulfport, the base of the 21st Antisubmarine Squadron, were added to the two classes already in existence.[27] Other directives permitted a classification of subdepots

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24. "Air Service Command Station List as of 1 December 1943."
25. "History of the 6th Sub-Depot from 1 November 1943 to 31 December 1943," in TSCHI-2 files.
26. "History of the San Bernardino Air Service Command," Sec. 5A.
27. AAF Reg. 65-6, 11 Jan. 1943.

within a given area into "control" and "satellite" installations. Thus, the Rome Air Service Command designated the 46th Subdepot at Houlton, Maine, a satellite of the 335th Subdepot at Presque Isle--one of the relatively few instances when this plan was carried out.[28] The subdepot and post commanders were continually urged to recognize the necessity for cooperation and full understanding of each other's problems. In 1942 and 1943 responsibilities of both commanders were reiterated and suggestions made for effecting the sorely needed cooperation.[29]

Definitive instructions bearing on subdepot maintenance activities were issued by the Maintenance Division, Air Service Command, in October 1943. Here were set forth (1) the authorized civilian ratings for maintenance employees, (2) the duties of the maintenance officer, the superintendent of the aircraft shops, and other key personnel, and (3) the responsibilities of the various branches of the Maintenance Department, such as the Sheet Metal Repair Branch of the Manufacture and Repair Section (see Figure 5).[30] Instructions as to the actual work of third echelon maintenance inspections and repair to be performed by the subdepots were left to Technical Orders and similar publications.[31]

The original plan of manning all subdepots with civilians and of releasing those military units which had been performing subdepot

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28. GO 51, Hq., Rome Air Service Command, 22 June 1943, in AAG 333.3, Sub-Depots. See also Col. E. P. Gaines, CO, Abilene Air Base to CG, 3d AF, 22 June 1943, Confidential, in TSAGD 323.3, Organization--Subdepots (C).
29. AAF Reg. 65-30, 28 Oct. 1942; and memo, Maj. Gen. George E. Stratemeyer, Chief of the Air Staff, to all air forces and commands in the United States, 1 April 1943, in AAG 323.3, Subdepots.
30. Maint. Div. Circular 17, Hq., ASC, 25 Oct. 1943, in files, Maint. Control Sec., Maint. Div., Hq., ASC.
31. Maintenance inspection and repair procedures are described in Chap. V and elsewhere in this study.

functions has already been mentioned. Inasmuch as the trained military service units were in great demand for overseas operations at the beginning of the war, close watch of the "civilianizing" process was maintained by Headquarters, AAF. As early as January 1942, the control depots were notified of the need of expediting this program and were reminded that July 1942 was the deadline for the release of military personnel.[32] Nevertheless, it was soon found impossible to provide sufficient civilians at all installations, especially those in isolated sections of the country where the climate was undesirable and adequate housing unavailable. Consequently, service squadrons were stationed at approximately 15 bases,[33] a number of them Operational Training Unit bases, for the purpose of providing third echelon maintenance and supply.[34]

The Transfer of the Subdepots

Throughout the first two years of the war, the large and steadily increasing network of subdepots operating, as described above, under

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32. Col. L. T. Miller, C/S, Mat. Div. to CO, SAD, 5 Jan. 1942, in TSAGD 323.3, Organization--Subdepots.
33. The number was variable inasmuch as winter training was not carried on at some northern bases.
34. Memo, Col. J. C. Gordon, Program Planning Office, Hq., ASC for Control Office, Hq., ASC, 6 April 1943, in TSCHI-2 files; Col. J. A. Pierce, Acting Chief, Training and Operations Sec., P&T Div., Hq., ASC for CG, AAF, 15 Sep. 1943, in AAG 323.3, Sub-Depots; and Col. P. E. Ruestow, Chief, Serv. Organizations Br., AC/AS, M&D to CG, ASC, 24 Sep. 1943, in TSAGD 323.3, Organization--Subdepots (C). Some of the militarized and partially militarized installations mentioned in these letters were the 1st Subdepot, Alamogordo, N. M.; the 30th, Ephrata, Wash.; the 371st, Marana, Ariz.; and the 409th, Tonopah, Nev.

the Air Service Command, carried an immense burden of maintenance work which otherwise would have fallen on the line crews at the flying fields and the air depots, particularly on the latter. Nevertheless, the administration of the subdepots and their efficiency did not escape a certain amount of adverse criticism, and at last, on 1 January 1944, command control was transferred to the other commands and the air forces using their facilities.

The principal reasons for the transfer appear to be three in number. The first and by far the most important was that unified control of an air base, which many considered essential to efficient operations, could not exist so long as there were separate base and subdepot commanders, each responsible to a different authority. A frequently encountered issue was disagreement between the two commanders over when the aircraft on the base were to be grounded for maintenance inspection. The conflict between the policies of unified control and parallel chains of command has already been mentioned. It has been pointed out that the Commanding General of the GHQ Air Force objected strongly to the division of tactical and service responsibilities on an air base. Also, in 1942, the Commanding General of the Troop Carrier Command stated that he did not want subdepots on his bases, apparently because of the division of responsibilities these installations entailed.[35] Notwithstanding such

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35. The reply of the technical inspector was to the effect that the Troop Carrier Command stations should perform properly their first and second echelon maintenance, which evidently the subdepots had been doing for them, before requesting the withdrawal of the subdepots. Lt. Col. Floyd Lundell, AAF Technical Inspector, to the Dir. of Technical Inspection, Hq., AAF, 15 Oct. 1942, in AAG 323.3, Subdepots.

objections, subdepots were installed at all AAF bases where there were sufficient airplanes; new activations continued through 1943 to the eve of the transfer.[36]

Throughout 1942 and 1943, there were symptoms of the anticipated jurisdictional disputes between post and subdepot commanders. The frequent occurrence of provisions in the regulations already discussed for effecting liaison between the two commanders is sufficient evidence that there was awareness of the problem. These provisions were reinforced in July 1943 by a teletype to the depots reporting that General Arnold's attention had been called to the failure of cooperation on the air bases and that remedial action should be taken at once.[37] One of the most fertile sources of conflict was the line of demarcation between first and second echelon work, which was to be performed by line crews under the jurisdiction of the post commander, and third echelon work, the responsibility of the subdepot commander.[38]

An analysis of other difficulties was presented by the Gulf Coast Training Center. The station commander, it was pointed out, did not have control over (1) work priorities established in subdepots, (2) vital supply activities, (3) equipment undergoing repairs, and

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36. The First Air Force requested that four new subdepots be activated in December 1943. (Brig. Gen. George F. Schulgen, C/S, 1st AF, to CG, ASC, 27 Dec. 1943, in TSAGD 323.3, Organization—Subdepots (C).) No more subdepots were to be activated after April 1944. R&R, Comment No. 2, Lt. Col. Alvin R. Guyler, Chief, Manpower Div., Management Control, Hq., AAF to Maj. C. Haymes, Air Serv. Div., AC/AS, M&D, 6 April 1944, in AAG 323.3, Subdepots.
37. TWX ASCEX, Maj. Gen. Walter H. Frank, CG, ASC, to all depots, 7 July 1943, in ibid.
38. Chief, Serv. Organizations Br., M&D to Gen. R. C. Cande, 26 Jan. 1944, in ibid.

(4) engineering flight test activities. It was suggested that these limitations on the station commander's authority were sometimes detrimental to the fulfilment of his mission, and that conferences with the subdepot commander could not be relied on to adjust the difficulties. Further instances were cited in which a subdepot commander had given higher priority to transient aircraft maintenance than to post maintenance and the belief was stated that station commanders and station personnel were frequently better qualified in engineering than subdepot personnel. The conclusion was that "to have the sub-depot as a separate organization on a post is entirely foreign to the theory and practice of military organization and control, and efficiency and operation are dependent entirely upon the personalities of the two commanding officers concerned. Any type of organization which is dependent upon personalities . . . is due for a good revision."[39]

Differences between post and subdepot commanders were by no means universal, as is borne out by reports of inspections.[40] Maj. Robert Bruce White of Base Services, Headquarters, AAF, in one of his always colorful reports, stated that the commanders of the 311th Subdepot at Foster Field and the 367th at Aloe Field were on excellent terms with their respective station commanders. However, he could commend neither installation on its record of efficiency.[41]

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39. Lt. Col. Hal M. McCord, Exec., Personnel Div., Hq., Gulf Coast Training Center, to Maj. Richard S. Wheeler, Hq., AAF, 14 Aug. 1943, in ibid.
40. See Excerpts from Field Representatives' Reports, enclosure to ltr., Maj. Raphael S. Gibbs, Fld Inspector, Hq., AAF, to Chief, Administrative Inspection Div., 11 May 1943, in ibid.
41. Maj. Robert Bruce White, AFRBS, to Brig. Gen. L. P. Whitten, Dir. of Base Servs., Hq., AAF, 13 Feb. 1943, in TSCHI-2 files.

The issue of unified command of the air bases had ramifications reaching into other branches of the Army and even into the General Staff. In the summer of 1942, the Services of Supply, later the Army Service Forces, proposed that it take over base administration for the Army Air Forces just as for the Army Ground Forces. Already under consideration, however, was a plan to enlarge Air Service Command control at continental air force bases to include, not only maintenance and supply, but housekeeping facilities as well. The Services of Supply proposal was rejected on the grounds that so great a change in existing arrangements during wartime might be hazardous, but neither could the Air Staff agree to accept the Air Service Command plan. No change, then, resulted in the status of the air bases in 1942.[42] Nevertheless, it was suggested that the decision a year later to transfer the subdepots was connected with the earlier attempt to increase Air Service Command control. The theory underlying this suggestion was that continuing complaints directed against the Air Service Command concerning confusion in the subdepots might prompt another effort on the part of the Services of Supply to assume administrative responsibilities on the air bases, and that such a tendency could be effectively neutralized only by transferring the subdepots and unifying command control at all bases.[43]

A second argument for transferring the subdepots was based on reports of inefficiency, apart from any question of unified command. In 1942,

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42. A fuller account of this matter is to be found in ASC Administrative History, pp. 71-75.
43. Notes on General Frank's meeting with the division chiefs, 16 Nov. 1943, in TSCHI-2 files.

Maj. Gen. Muir S. Fairchild reported that the Second Air Force was complaining that the subdepots worked so slowly and inefficiently, particularly in changing engines, that airplanes were out of commission longer than they might have been had the line crews done the work themselves. He also found that the Geiger Field Subdepot was not competently staffed. At the same time, General Fairchild admitted that the subdepots "vary tremendously from place to place. At one place the tactical organizations have nothing but praise for the sub-depot system, while at the very next stop they have nothing but condemnation for the subdepot at their place." The determining factor, he concluded, was whether the subdepot commander was a competent man.[44]

In 1943, the Flying Training Command reported inefficiency, particularly in subdepot supply arrangements,[45] and in the letter from the Gulf Coast Training Center already cited, the charge of incompetence in subdepot personnel was made.[46] Field representatives found some installations to have a low production rate in relation to the large size of their maintenance staff, but others, like the 309th, Tuskegee, Ala., they praised highly.[47]

The Air Service Command customarily replied to charges of inefficiency by pointing out that the flying organizations were not

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44. R&R, Maj. Gen. Muir S. Fairchild, AFDMR, to Dir. of Base Servs., Hq., AAF, 21 Aug. 1942, in AAG 323.7J, Depots and Subdepots.
45. Lt. Col. Adnell O. Acres, Asst. AG, Hq., Flying Training Comd to CG, AAF, 19 June 1943, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment (1942-1943).
46. Lt. Col. Hal McCord, Exec., Personnel Div., Hq., Gulf Coast Training Center, to Maj. Richard S. Wheeler, Hq., AAF, 14 Aug. 1943, in AAG 323.3, Subdepots.
47. Excerpts from Field Representatives' Reports, enclosure to ltr., Maj. Raphael S. Gibbs, Fld Inspector, Hq., AAF, to Chief, Administrative Inspection Div., Hq., AAF, 11 May 1943, in ibid.

performing properly the first and second echelon inspections and repairs for which they were responsible. The result was that the subdepots had to accomplish first and second echelon work simultaneously with their third echelon responsibilities. Also, the neglect of preventive maintenance by the flying organizations tended to increase the rate of deterioration and make for more frequent repairs and replacements. According to a report of General Frank, Commanding General of the Air Service Command, 70 per cent of the investigations of complaints about poor subdepot service revealed that the real difficulty was inadequate first and second echelon maintenance.[48]

A third factor that contributed to the unpopularity of the subdepot system, particularly in its initial phase, was the fact that the replacement of experienced enlisted mechanics at the air bases by civilian workers, most of them unskilled, was considered unwise. Pilots, long accustomed to having base maintenance performed by military personnel, were fearful that civilian mechanics could not be trusted to do the work adequately. The civilian installations were fairly well organized by the spring of 1942, however, and such fears proved groundless. Further, it was considered that taking the military personnel out of the air base maintenance shops deprived the AAF of a natural, on-the-job training installation for new military mechanics. With the formation of the civilianized subdepots, shop facilities had to be duplicated at training posts and some practice maintenance jobs set up to provide for the

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48. Telephone conversation, Maj. Gen. Walter H. Frank, CG, ASC, to A-4, Air Staff, Hq., AAF, 7 May 1943, in TSAGD 452.031, Maintenance and Repair of Aircraft.

necessary training of military personnel. On the other hand, some military training was conducted in the civilian subdepots.[49]

The decision to transfer the subdepots to the other commands and the air forces was, strictly speaking, an AAF Headquarters decision, and it came about, according to available evidence, as the result of the several factors just discussed. Final decision seems to have been reached on 11 November 1943.[50] As late as 10 November of that year, the complete control of the subdepots by the Commanding General, Air Service Command, was reaffirmed.[51] But at a division chiefs' meeting on 13 November, General Frank announced that all subdepots were to be taken away from the Air Service Command and assigned to the various air forces and commands with which they operated.[52] At the same time, General Frank wrote AAF Headquarters that, although he had not been asked to comment, he felt he should state his opinion of the serious consequences of the transfer. Among these consequences he listed the increase in manpower he thought would be necessary, increase in spare

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49. Interview with Lt. Col. C. A. Dixon, General Staff, G-4 Sec., 20 July 1945.
50. General Arnold sent a letter to General Frank, 20 December 1943, commending him for his "spirit of cooperation." The following statement about the decision appears in this letter: "On 11 November 1943, the Chief of Air Staff approved a plan whereby sub-depots would be placed under the command jurisdiction of the command or air force with primary interest in the stations which the sub-depots served. Meetings were held at this headquarters with representatives of the Air Service Command and the Fourth Air Force on 22 November, with representatives of the air forces and commands on 25 November, and at Patterson Field on 6 and 7 December 1943." Gen. H. H. Arnold, CG, AAF, to CG, ASC, 20 Dec. 1943, in AAG 201.22, Commendations.
51. AAF Reg. 65-6, 10 Nov. 1943. In this regulation, the engineering unit of the subdepot is called the "Maintenance Division" for the first time.
52. Notes on General Frank's meeting with the division chiefs, 13 Nov. 1943, in TSCHI-2 files.

parts, lessened efficiency in third echelon maintenance, and loss of accuracy in reporting basic information.[53] Despite the criticism of subdepot administration then current, the news of the decision to transfer occasioned some surprise. Within Headquarters, AAF the move had not been coordinated with the Office of AC/AS, MM&D, the normal channel for Air Service Command matters,[54] and at a conference of members of that staff section on 25 November, several officers commented unfavorably on the transfer.[55]

At first, there was uncertainty concerning whether the transfer would also involve such installations as the intransit depots,[56] but at length a plan, which had been worked out by the interested commands and air forces,[57] was announced on 22 December. Here it was stipulated that, effective 1 January 1944, the commanding generals of the air forces and commands would, in addition to their other responsibilities, assume command of all subdepots, militarized and civilian, of satellite installations, and of air depot detachments.[58] The Air Service Command was left with responsibility for (1) establishing engineering standards through the publication of Technical Orders and other instructional material, (2) overhaul of aircraft, engines, and other equipment at the

53. Maj. Gen. Walter H. Frank, CG, ASC, to CG, AAF, 20 Nov. 1943, in AAG 323.3, Subdepots.
54. Interview with Lt. Col. Clarence Haymes, Exec., AC/AS, MM&D, 24 July 1945.
55. Confidential memo report, Col. Thomas B. McDonald, Chief, Maint. Control Sec., Hq., ASC, for CG, ASC, 23 Nov. 1943, in TSAGD 337, Conferences (C).
56. Notes on division chiefs' meeting, 27 Nov. 1943, in TSCHI-2 files.
57. General Frank participated in the conference and was commended for his "progressive attitude." Maj. Gen. Walter H. Frank, CG, ASC, to CG, AAF, 9 Dec. 1943, in General Frank's file (C), TSAGD; Gen. H. H. Arnold, CG, AAF, to Maj. Gen. Walter H. Frank, CG, ASC, 20 Dec. 1943, in AAG 201.22, Commendations.
58. Air Depot Detachments are discussed briefly in Chap. II.

air depots, and (3) conducting quarterly inspections of the subdepots to insure that maintenance and supply activities were carried on properly.[59] That is to say, the tactical organizations were again given control of air base, or third echelon, maintenance, in addition to first and second echelon, and the subdepots became subordinate to the base commanders. The following year, the Air Service Command (by that time renamed the Air Technical Service Command) was authorized to use subdepot facilities to handle special projects upon the approval of the air force or command concerned.[60]

The effect of the transfer on the efficiency of the subdepots may not be hastily judged. The progress of the war and the reduction of training permitted the inactivation of some installations and there were fewer requests for new activations.[61] That is, by the time the transfer took place, the subdepots were better stabilized because new and untrained personnel were no longer being added to the maintenance force, and the result was a generally higher experience level and greater efficiency. There is some evidence that the tactical organizations missed the guidance of the Air Service Command. The Second Air Force, for example, requested the Mobile Air Service Command to resume the rating of the subdepots, a plan which had been dropped.[62] Again, the Commander of the 10th Subdepot at Keesler Field, Miss., wrote that

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59. AAF Reg 20-31, 22 Dec. 1943.
60. AAF Reg 20-31, 31 Aug. 1944.
61. The Air Service Command retained responsibility for activating subdepots. Maj. Gen. Delmar H. Dunton, Dep. Comdr, ASC, to CG, AAF, 20 Jan. 1944, in TSAGD 323.3, Organization--Subdepots (C).
62. Capt. A. W. Seibt, Asst. AG, Hq., 2d AF, to CG, MOASC, 18 Jan. 1944, in ibid.

the greatest disadvantage of operating under the Training Command rather than the Air Service Command was that the Mobile Air Depot could no longer freely send in additional maintenance personnel to assist the subdepot with technical problems and to handle abnormal work loads. He further declared that, because the interchange of personnel and work loads among subdepots was no longer possible, his own activity and the other subdepots could not render efficient service.[63] Also, the Office of the AC/AS, MM&D went on record to the effect that the subdepots were left in a state of confusion by the transfer.[64]

Having acquired command control of the subdepots, several AAF organizations complained that the area air service commands were refusing to supply them with parts needed for the overhaul of particular items of equipment, such as landing struts. The performance of overhaul at a few subdepots was justified, in the opinion of these organizations, on the grounds that the Air Service Command had farmed out fourth echelon projects to subdepots from time to time in the past. To such complaints, the Air Service Command replied that the policy was to authorize no overhaul at the subdepots.[65] Pains were also taken to

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63. Lt. Col. W. E. Dawes, CO, 10th Subdepot, Keesler Fld, to CG, MOASC, 18 Jan. 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment (1944).
64. R&R, Comment No. 1, Brig. Gen. L. P. Whitten, AC/AS, MM&D, to Management Control, 19 Jan. 1944, in AAG 323.3, Subdepots.
65. Some acerbity is to be noted in the complaints addressed to the Air Service Command. Brig. Gen. U. G. Ent, CG, 2d Air Force, to CG, ASC, 9 Feb. 1944, in ibid. and in the replies thereto; Col. L. S. Vance, AC/S, A-4, Hq., Eastern Flying Training Comd, to CG, Training Comd, 18 Feb. 1944, in ibid.; Col. Herbert M. Newstrom, CO, AAF Pilot School, Majors Fld, Texas, to CG, ASC, 25 April 1944, in ibid.; Col. S. E. Prudhomme, Chief, Maint. Div., Hq., WTASC, to CG, 3d AF, 7 Feb. 1944, in ibid.

point out that the air forces should concentrate on better first, second, and third echelon maintenance, inasmuch as airplanes received at the depots had showed certain deficiencies.[66]

In accordance with the announced policy, air depots were directed not to allocate projects to the subdepots without clearance from the headquarters both of the Air Service Command and of the command or air force controlling the subdepot concerned.[67] Again, when a report was received that the subdepot at Amarillo, Texas, had accomplished "almost complete" overhaul of certain engines, although not equipped with the proper holding fixtures and aligning bars, the Air Service Command reported the matter and an investigation followed.[68] The findings of the Air Inspector were that the alleged overhaul had not, in fact, been accomplished, and that there was no violation by the Amarillo Subdepot of the provisions of Technical Order No. 00-25-4.[69]

Several reports, belonging to the first half of 1944 and representing the view of the Air Service Command, contended that subdepot efficiency suffered as the result of the transfer, although there were instances of "extremely capable operation." The principal causes for lessened efficiency were given as follows: (1) subdepot officers at some installations were replaced by untrained base officers, a move

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66. Maj. Gen. Walter H. Frank, CG, ASC, to Brig. Gen. U. G. Ent, CG, 2d AF, 22 April 1944, in ibid.
67. Lt. Col. Edward G. Kiehle, Acting Chief, Control Sec., Maint. Div., Hq., ASC, to CG, FASC, 4 April 1944, in TSAGD 323.361, Powers and Duties.
68. Col. Don Coupland, Chief, Engine Sec., Maint. Div., Hq., ASC, to CG, AAF, 3 April 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment (1944).
69. Col. Lewis A. Dayton, Fld Air Inspector, to CG, AAF, 17 April 1944, in ibid.

which seriously affected morale; (2) each command and air force pursued its own policies for subdepot operation, causing confusion among subdepot personnel; (3) no proper policy for distributing work loads among the subdepots was evident; (4) regulations and good practice were being violated in the performance of maintenance and supply; and (5) at some bases, visits to the air depots and visits by air depot personnel were discouraged.[70] The Commanding General of the Fairfield Air Service Command also believed that wide differences in the interpretation of regulations had sprung up at the subdepots since the transfer.[71] In Col. Ward Wheelock's report for 30 May 1944, however, several area commanders were quoted to the effect that their former subdepots appeared to be operating satisfactorily and that many of the earlier difficulties were being eliminated. In the same report it was indicated that the Second Air Force might decide to recommend the return of the subdepots to the Air Service Command, a hope which was not fulfilled.[72]

As opposed to the ASC view that the transfer was injurious to maintenance efficiency, the attitude of the Air Staff was that administrative relations were thereby improved without any real impairment of

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70. Col. Ward Wheelock, Control Officer, Hq., ASC, to CG, ASC, 17 March 1944, in TSAGD 323.3, Organization--Subdepots (C).
71. Brig. Gen. Clarence P. Kane, Notes on Subdepot talk, 5 April 1944, in TSCHI-2 files.
72. One of the difficulties that was cleared up, according to the Commander of the Rome Air Service Command, was the tendency of the First Air Force to report the number of grounded aircraft on Form No. 110 in such a way that it appeared that the Air Service Command was not carrying out its responsibilities. (Col. Ward Wheelock, Control Officer, Hq., ASC, to CG, ASC, 30 May 1944, in TSAGD 323.3, Organization--Subdepots (C).) Some of these reports were forwarded to Headquarters, AAF. Maj. Gen. Delmar H. Dunton, Dep. CG, to CG, AAF, 8 May 1944, in ibid.

efficiency. This attitude is particularly well borne out in a memorandum report of a conference held at Headquarters, ASC, 6 April 1944. Here, the representatives from the Office of the AC/AS, MM&D, stated as their opinion that, although the conference had been requested by the Air Service Command ostensibly for the purpose of discussing minor deficiencies in the regulations which effected the transfer, it became apparent that "the main objective was to discredit the command decisions made in December when the sub-depots were transferred," and further that "the Air Service Command had never mentally lost the sub-depots and constantly had a hope that they would be returned to them under their jurisdiction." General Frank, Colonel Wheelock, and Brig. Gen. Clarence P. Kane, Commander of the Fairfield Air Depot, were the principal speakers at the conference, and in turn they charged that, by reason of the new administration of the subdepots, stock control procedures had broken down, that the resulting deterioration of maintenance had caused a rise in the accident rate of the Second Air Force, and that there was a dangerous tendency for the other commands and air forces to place incompetent people in the former subdepots. In the memorandum report of the conference, most of these adverse criticisms were answered by comments based upon special reports and interviews with a number of subdepot, depot, and air force administrators. For example, General Frank's statement that the accident rate of the Second Air Force had risen because of poor maintenance was refuted by statistics from the Office of Flying Safety to the effect that no real changes had in fact occurred in the accident rate since the transfer. The other

answers also suggested that the Air Service Command tended to exaggerate some of the difficulties resulting from the transfer.[73]

It does not lie within the purpose of this study to evaluate the subdepots in any final sense or to conclude that, under the auspices of one command, they fulfilled their mission in the winning of the war better than would have been possible under another. The evidence presented above would seem to support the view that two aspects of subdepot efficiency may be distinguished--namely, (1) ease of administration of individual subdepots, and (2) the industrial or engineering efficiency of the subdepot system as a whole--and that the conditions favoring one did not necessarily favor the other. In other words, prior to the transfer the air forces and commands were naturally inclined to judge the subdepots on their bases from the standpoint of administrative relationships and local efficiency; the Air Service Command just as inevitably tended to consider the 238 subdepots largely from the standpoint of over-all effectiveness as engineering establishments, as units of a nation-wide factory. Thus, if the transfer of the subdepots from the Air Service Command to the control of the individual organizations using their facilities were to be regarded as highly desirable or even necessary, administratively speaking, it could at the same time be considered quite undesirable in the light of total industrial efficiency.

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73. Memo report, Col. V. J. Harrington, Manpower Div., Management Control, Hq., AAF, Lt. Col. P. E. McElroy, MM&D, and Maj. E. V. Quigley, Organizational Planning Div., Management Control, 1 May 1944, in AAG Mgt. 4.

The subsequent history of the installations which were activated as subdepots may be quickly related. The subdepots were taken over as units by post commanders, and at a majority of bases the former subdepot commanders continued to function much as before under the title of Director of Supply and Maintenance.[74] For a time, the term "subdepot" and also the number designations persisted in use although they had been officially discontinued.[75] At the many bases of the Training Command, the former subdepot Maintenance Division came to be known as the Shop Maintenance and Engineering Unit. Unless changes were made in the number of assigned aircraft or in the mission of a particular air base, the size and composition of the civilian staff performing third echelon maintenance was not altered.[76]

After the absorption of the subdepots and the integration of miscellaneous maintenance activities, such as vehicle repair, already mentioned,[77] the Maintenance Section of a typical large air base was made up of the following units:

1. Aircraft Maintenance Organizations
2. Shop Maintenance and Engineering
3. Transient Aircraft
4. Refueling
5. Engine Change
6. Communications Maintenance and Operations
7. Automotive Maintenance and Operations
8. Armament Maintenance

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74. Ibid.
75. AAF Reg. 20-31, 31 Aug. 1944, Sec. IV, par. 5c.
76. "Station History, Selman Field, 1 September-31 October 1944," p. 83.
77. See Chap. II.

The Aircraft Maintenance Organizations comprised the squadrons and groups assigned to flight-line work and to 50- and 100-hour inspections, which activities were frequently operated on the "Production Line Maintenance" (PLM) system.[78] At primary training schools, inspections and first and second echelon maintenance, when under production-line maintenance methods, were found to require a ratio of about one man per airplane in service. Multiengine and tactical aircraft required a higher proportion of maintenance men, however.[79] The Shop Maintenance and Engineering Unit, the former subdepot Maintenance Division, was civilian-operated, of course, and consisted of a variable number of departments, such as Metal Manufacture and Repair, Instrument Repair, Parachute Repair, Typewriter Repair, and Shoe Repair. Third echelon aircraft work was the principal function of this unit just as it had been under the Air Service Command, although some overhaul and repair of accessories and other items of materiel and minor aircraft repairs that could not be accomplished in the inspection line were also performed. The functions of the six other units listed above, such as Engine Change and Refueling, are evident from their names.[80] Just as before the transfer of the subdepots, airplanes in need of general overhaul or of repairs beyond the facilities of the air base were sent to the appropriate depot.

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78. For a discussion of production-line maintenance, see Chap. V.
79. "History of the Western Flying Training Command, Installment VI, 1 September-31 October 1944," p. 542.
80. "Station History, Selman Field, 1 November-31 December 1944," pp. 66-79.

Chapter IV

MAINTENANCE POLICIES

Sources of Maintenance Information

During the period 1939-1945, maintenance policies were formulated in much the same way as in preceding years.[1] Also, as in the past, the work of establishing policies was divided between Wright Field and AAF Headquarters in Washington. In general, the directives covering the broadest aspects of maintenance--"what to do"--were prepared by the Air Services Division of Materiel and Services (or predecessors), Headquarters, AAF, whereas specific technical instructions--"how to do it"--were the responsibility of the Maintenance Division at Wright Field.[2] Examples of the kind of policy directives emanating from Washington and those prepared at Wright Field are given throughout this discussion.

The formulation of maintenance policies and intelligent supervision of maintenance operations at the air depots and bases throughout the air arm necessitated a steady flow of reliable data from the operating units to both AAF Headquarters and Wright Field. During the war years, this flow of information was considerably augmented. In particular, important

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1. See ATSC historical monograph, "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," pp. 8-29.
2. Interview with A. E. Beesley, Tech. Asst., Air Servs. Div., AC/AS, M&S, 20 July 1945. Strictly speaking, many of the directives issued by Wright Field had to do with depot organization and definitions of terms and then could not be regarded as "how to do it" directives.

new reports were prepared by the Statistical Control Unit which, after September 1942, began to regularize the reporting system of the Army Air Forces.[3] The principal sources of maintenance information, then, were (1) basic airplane records, Forms No. 1 and 41, (2) reports of inspectors, (3) Unsatisfactory Reports, (4) conferences, (5) Depot Cost Report and Monthly Report of Depot Maintenance Activities, and (6) miscellaneous sources of maintenance information.

Basic Airplane Records, Forms No. 1 and 41. These two AAF forms, accomplished for each airplane in the air arm by pilots and maintenance personnel, continued to serve, in a sense, as the basic record of AAF activities. Form No. 1 (and 1A), the Flight Report,[4] recorded the model and serial number of the airplane, the names of the pilots, the crew chief, and passengers, the number of flying hours day by day, and condensed information about servicing and maintenance. Form No. 41, the Maintenance Inspection Record, provided a detailed day by day check of inspection and maintenance operations for the airplane. Originally issued as a large, single sheet which was affixed to a board,[5] it later appeared as a pamphlet (Form No. 41B). Also, it was simplified when special inspection check lists were developed for each model of airplane.[6] During 1944, a new form combining Forms No. 1 and 41B was devised for service test, but final adoption was delayed pending the end of the war.[7]

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3. ATSC historical monograph, "History of the Control Function, ASC, 1942-1944," pp. 59-85.
4. See "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," Figures 3 and 4.
5. See ibid., Figure 5.
6. These inspection forms are discussed later in this chapter.
7. "Maintenance Division Annual Report, 1944," p. 10 and Exhibit B, in TSCHI-2 files.

Neither of these forms was itself sent to higher headquarters, except for purposes of a special study,[8] but together they formed in one way or another the basis for many routine reports, such as the Airplanes Grounded for Parts Report, which were of great value as an index to maintenance operations.

Reports of Inspections. The reports of technical inspectors who had direct contact with the operating elements were of considerable interest to the headquarters administering maintenance matters. In 1940, the inspection system was controlled by the Inspection Division of the Office of the Chief of the Air Corps through the establishment of policies and standards. Inspections of the air depots, including maintenance and supply facilities and operations, were accomplished by one or more Technical Supervisors stationed at each depot. At the stations, Technical Inspectors performed those functions. Copies of the reports of the technical supervisors were regularly routed to the Chief of the Materiel Division for the use of interested persons.[9] In general, this system continued in effect through the period 1939-1945, except that the multiplication of air installations made some decentralization necessary. In the Air Service Command[a] supervisory office was set up which, early in 1943, when it became known as the Air Inspector's Office, ASC, assumed control of technical as well as

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8. Memo report, Proceedings of a Board of Officers Convened for the purpose of Studying Problems Involved in Connection with the Unsatisfactory Report Inspection Procedures, Wright Field, 12 Feb. 1940, in TSAGD 334.7, Boards of Officers.
9. See Part I, pp. 11-12 of memo, Maj. Gen. H. H. Arnold, C/AC, for chiefs, all divs., 20 Feb. 1940, in AAG 333.1J, Inspections, Fields and Posts.

tactical and administrative inspections of Air Service Command activities and forwarded such reports to Washington. In addition to its purely administrative functions, the Air Inspector's Office, ASC made inspections with the cooperation of specialists from the various units of ASC Headquarters, such as the Maintenance Division.[10] In each area air service command, there was a similar air inspector's organization with analogous duties.[11]

Examples of inspector reports will indicate their usefulness as a source of information about maintenance needs. After an inspection tour in January 1942, a technical inspector rated the engineering activities at Fairfield Air Depot as excellent, but recommended that badly needed rail facilities be provided. The same report rated maintenance at the Selma, Ala. Subdepot very satisfactory and suggested that safety precautions be increased.[12] Later in 1942, the Director of Technical Inspection instructed all supervisors to pay particular attention to the adequacy of aircraft maintenance at the bases they visited.[13] Sometimes inspections of maintenance and supply installations were conducted as joint enterprises. In October 1942, inspectors from Headquarters, AAF, from the Air Service Command, and from the Second Air Force visited 11 bases of the Second Air Force and held conferences on maintenance and supply problems with subdepot and station commanders.

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10. R&R, Comment No. 2, Brig. Gen. Carlyle H. Ridenour, Air Inspector, ASC, to Hist. Sec., ASC, 31 Aug. 1944, in TSCHI-2 files.
11. ASC Manual 20-1, 15 March 1943, in TSCHI-2 files; ASC Reg. 20-1FF, 25 April 1944.
12. Lt. Col. Ray H. Clark, Air Corps Techn. Supervisor, to C/AC, 16 Jan. 1942, in TSAGD 333.1, Technical Inspections (Jan.-March 1942); Lt. Col. Ray H. Clark to C/AC, 29 Jan. 1942, in ibid.
13. Special Instructions 39, Hq., AAF, 15 Aug. 1942, in AAG 452.1-4B, Airplanes, Using, Wearing, Maintaining, Operating.

The high percentage of Second Air Force airplanes out of commission at that time was ascribed to the poor experience level of maintenance personnel, the critical shortage of certain parts, and inadequate shop facilities.[14]

There are many instances of informal visits or inspections by the Chief of the Maintenance Division, ASC,[15] and frequently reports of unusual conditions were investigated by technical personnel sent out by the Air Service Command.[16] Informal visits to stations (principally Air Service Command activities) where engineering facilities were located continued to be made by Headquarters, AAF after the Air Service Command had established its own inspection organization. The reports of these inspectors, notably those of Maj. Robert Bruce White, already mentioned in connection with the subdepots, were highly regarded as an index to the general efficiency of maintenance activities.[17]

From November 1944 to February 1945, the Supply and Maintenance Division of the Office of the Air Inspector, Headquarters, AAF, in

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14. Maj. Gen. Robert Olds, CG, 2d AF, to CG, ASC, 3 Oct. 1942 (and incl.), in TSAGD 401, System of Supply.
15. Maj. Gen. Clements McMullen, for example, visited the Maintenance Division at Fairfield and called attention to certain deficiencies. Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to Lt. Col. J. E. Linebaugh, Eng. Officer, FAD, 3 July 1943, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.
16. Thus, reports suggesting poor overhaul procedure at San Antonio were investigated in 1943 by the Engineering Division. Memo report, Investigation of Cylinder Reconditioning, Overhauling, and Block Test Procedure at SAAD, 4 Aug. 1943, in ibid.
17. When the Air Service Command objected to the continued visits of Major White, Headquarters, AAF replied that the reports of such informal visits "have been of considerable value to this Headquarters." 2d wrapper ind. (Lt. Col. Robert Bruce White, Inspector, to Brig. Gen. L. P. Whitten, Office, AC/AS, MM&D, 4 Aug. 1943), Maj. Gen. Barney M. Giles, C/AS to CG, ASC, 23 Sep. 1943, in TSAGD 333.1, Inspection Trips.

conjunction with the Air Inspector, ATSC, conducted a thorough inspection of the maintenance divisions of the 21 depots. Detailed criticisms were made of such matters as the crowded plant lay-out at Middletown, the unused equipment and space at Miami, and the inefficient scattering of buildings at Mobile and San Antonio; and commendation was given to the work done at Accessory Repair Section at Oklahoma City, the Aircraft Repair Branch at Spokane, and to various other activities. Among the specific suggestions offered the Air Technical Service Command were the following: that the scheduling of work loads at the depots be improved by avoiding the tendency to change abruptly the type of engine or other equipment being overhauled in particular depots, that a cost accounting system be set up, and that the "bogy system," the plan of encouraging the depots to compete among themselves on the amount of equipment overhauled, be eliminated.[18]

Unsatisfactory Reports.[19] Unsatisfactory Reports (UR's) continued to serve as the primary source of information about specific technical difficulties. In 1939 and for two years thereafter, the UR was processed as follows: having been prepared by a flying organization on the subject of defective equipment, it was sent to the Field Service Section where it was recorded, classified, and assigned a serial number. If they felt competent to do so, the personnel of the Field Service Section

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18. Col. John H. Price, Chief, Supply and Maint. Div., Office of the Air Inspector, to Dir., ATSC, 28 Feb. 1945 (and previous reports by Col. Price on individual depots), in AAG 333.1, Inspections, ATSC.
19. A detailed history of UR's is in progress in the Historical Office, ATSC.

replied to the UR, outlining appropriate remedial action; otherwise it was sent to the Engineering Division for research. Copies were also sent to the contractors for research and manufacturing improvements.[20] The outbreak of war brought about two important changes: (1) the number of UR's submitted increased enormously, not only on account of the expansion of air power, but also because newly developed equipment was being pressed into service at an unprecedented rate; and (2) procedures clarifying the handling of UR's had to be formulated because of the overlapping functions of the Air Service Command and the Materiel Command.[21]

During the year 1944, a total of 169,521 UR's was received by the Maintenance Division, ATSC, an average monthly rate of 18,000 as compared with a total of not many more than 5,000 for the year 1939. To disseminate the flood of necessary answers, a Technical Order, the Unsatisfactory Report Digest, was issued twice each month beginning 20 February 1944. The UR Digest recorded not only specific failures and any action that was suggested but also the number of reports received on each failure.[22] Prior to the issuance of this publication, special digests and charts summarizing difficulties reported on particular airplanes and engines

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20. Office Memo 39-50, Mat. Div., 8 Dec. 1939, in Serv. Eng. files; Office Memo 41-31, Exper. Eng. Sec., Mat. Div., 2 Jan. 1941, in ibid.
21. There were occasions, prior to the merger, when both commands sent the same UR's to a contractor for action, a situation that caused some confusion. Also, badly needed replies to UR's were often delayed because of the great flood of research work that accumulated. See the ATSC study on UR's.
22. "Maintenance Division Annual Report, 1944," pp. 12-13.

were prepared from time to time.[23] Some of these digests amounted to technical discussions designed to help maintenance personnel with their duties. In a 1941 summary, for example, failures of master rod bearings in the R-1820 engine were attributed to lack of lubrication at the time of starting newly installed engines and also to the use of improper cleaning solutions, and instructions for making pre-oiling modifications were given.[24]

Conferences. Direct consultation on maintenance problems at the annual Engineering Supply conferences proved to be of great value to the Materiel Division in the formulation of maintenance policy. Here, engineering personnel from the air depots and the other operating elements compared experiences, exchanged advice, offered suggestions for technical and administrative improvements, and commented on the practicability of the proposals for future operations. Contractors' representatives also attended as technical consultants. These conferences were continued as joint maintenance and supply meetings on an annual basis until the beginning of the war. Thereafter, maintenance and supply personnel generally met separately and at different times,

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23. Maj. F. O. Carroll, Chief, Exper. Eng. Sec., Mat. Div., to Chief, Prod. Eng. Sec., Mat. Div., 10 Jan. 1940, in Serv. Eng. files; Lt. Col. F. O. Carroll, Chief, Exper. Eng. Sec., to Chief, Prod. Eng. Sec., 12 Feb. 1941, in ibid.; R&R, AC/AS, MM&D to TAI (inclosure), 9 Dec. 1943, in AAG 319.1, No. 1, Unsatisfactory Reports, 24 Sep. 1942-31 Oct. 1943; Memo Report No. W-U-Eng-57-8133-1, Add. 9, Eng. Div., Mat. Comd., in TSAGD 452.13, Engines, General; "Special UR Digest for B-25 Series Airplanes," in TSAGD, Maj. Gen. Walter H. Frank's files (C).
24. Lt. Col. F. O. Carroll, Chief, Exper. Eng. Sec., to Chief, Prod. Eng. Sec., 8 Aug. 1941, in Serv. Eng. files.

principally because the delegates had become much more numerous. Also the conferences, many of which were limited to particular subjects, were held at much more frequent intervals than formerly.[25]

The old tradition of convening the key maintenance personnel of the depots for a general discussion of problems was continued, however, in such meetings as that held at Kelly Field on 22 and 23 March 1943. The purpose of this meeting, according to Col. J. T. Morris's opening remarks, was to consider the difficulties of each depot. Mr. Vic Meyers of Headquarters, ASC then discussed the newly organized Maintenance Control Section and read a proposed Technical Order dealing with the localizing and specializing of engine overhaul at the depots. Such a policy was necessary to provide for better scheduling and for more standardized overhaul procedures for each of the various engines. Control of the subdepots by the depot engineering officers was later discussed as was the application of production-line methods to the overhaul of various items of equipment. The Oklahoma City Air Depot was pointed out as having a model set of engineering shops. Many complaints were voiced about the increased work loads at the depots resulting from poor first and second echelon maintenance at the air bases. Also, matters of shop practice, such as the use of clover seed for blasting pistons, were brought to the floor.[26] At another national maintenance conference

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25. For some time in 1943, bimonthly conferences of maintenance officers and general superintendents were held. Col. Joseph T. Morris, Asst. Chief, Maint. Div., ASC, to CO, OASC, 18 June 1943, in TSAGD 337, Conferences.
26. ASC Engineering Officers' Conference, Kelly Fld, 22-23 March 1943, in ibid.

held on 23 and 24 October 1944 at the Warner Robins Air Technical Service Command, personnel problems and the necessity of reducing drastically the vast stocks of reparable items were taken up first. Next, the proposed Depot Cost Report was described, and discussions were held on procedures for storing excess airplanes and for the cleaning of engines.[27]

Among the many other meetings bearing on maintenance but not held under the auspices of the Air Technical Service Command was a Commanding Generals' conference at Maxwell Field, on 19 and 20 February 1944, including representatives of all the air forces and commands. In the discussion of maintenance, the admitted shortcomings were ascribed to rapid expansion, lack of experienced personnel, changes in organization, and changes in aircraft. In order to improve conditions, it was recommended that production-line maintenance[28] be used more extensively, that better cooperation be encouraged between stations and the air forces and commands, and that peak loads be transferred from one subdepot to another.[29]

Various small groups were assembled to work out specific problems from time to time. Thus, a meeting of maintenance personnel at the Air Technical Service Command on 22 and 23 January 1945 studied the problem of revising aircraft inspection periods and sent out requests to the other commands and the air forces to submit proposals on this matter.[30] Still other small conferences were called to investigate the maintenance procedures for highly specialized equipment such as radio and radar.

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27. Notes on conference, in "History of the Warner Robins Air Technical Service Command."
28. Production-line maintenance is discussed in Chap. V.
29. Memo report, Commanding Generals' Conference, AAF, Maxwell Fld, 19-20 Feb. 1944, in TSAGD 337, Conferences (C).
30. Col. John A. Ball, Chief, Control Sec., Maint. Div., ATSC, to CG, 1st AF, 27 Jan. 1945, in ibid.

Depot Cost Report and Monthly Report of Depot Maintenance Activity. The Depot Cost Report, issued at the end of each fiscal year, provided the Materiel Division with much valuable data about the volume of maintenance operations at the depots.[31] Cost reports were continued until the outbreak of war, when they were abruptly terminated because of the difficulty of maintaining such elaborate accounts of constantly changing wartime operations.[32] The last such report to be prepared covered the first half of the fiscal year 1942.

In place of accounting carefully for labor and material costs, the Air Service Command began compiling, on the basis of data from the depots, a record of the numbers and types of airplane and engine repairs accomplished, depot by depot, and of the total number of maintenance personnel, broken down into such categories as direct and indirect labor, male and female. Whereas in peacetime, the costs were the first consideration and the volume of work the second, in the desperate wartime race to arm the nation during 1942 and later, only the amount of work that had to be done was of importance. The new report, compiled on a monthly basis as early as January 1943, was called the Monthly Report of Depot Maintenance Activity. Changes were made in the form from time to time, but it remained the official summary of the maintenance operations of the Air Service Command.[33] The Statistical Control Unit

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31. Depot Cost Reports are the prime source for the production figures cited in "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," ATSC Historical Monograph.
32. Col. Joseph H. Hicks, C/S, ASC, to CO, FAD, 26 Aug. 1942, in TSAGD 121.6, Cost Accounting System.
33. The statistics on depot activities cited and discussed in Chap. VI are drawn largely from the Monthly Reports of Depot Maintenance Activity.

assumed full responsibility for the accuracy of the data of this report when the Air Technical Service Command was established on 1 September 1944.[34]

The necessity for cost accounting as a check on operational efficiency was never lost sight of, however, and late in 1944, a revised cost system was prepared at Headquarters, ATSC. The system was then installed at the Middletown Air Technical Service Command early in 1945 as a service test, and the first reports indicated it to be satisfactory.[35] The supposition was that the new system would be put in effect in all air depots later in 1945.

Miscellaneous Sources of Maintenance Information. Other reports which provided Headquarters, AAF with information about maintenance needs were AAF Report No. 110, Airplanes Grounded for Parts,[36] and the Air Service Command tables and charts of total tactical and trainer airplanes out of commission for maintenance or parts. Such data included airplane groundings for which both the flying organizations and the Air Service Command were responsible. Many other reports that were made routine in 1943 and later, like the Spare Engine Report, had an important although indirect bearing on maintenance and served to improve the efficiency of Headquarters control of maintenance throughout the Army Air Forces.[37] By these reports better information as to the

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34. Interview with Capt. C. E. Miller, Control Room, Hq., ASC, 17 May 1945.
35. "Maintenance Division Annual Report, 1945," p. 5.
36. This report was primarily of value to supply activities, but maintenance work, of course, was necessary to install the parts once they were available.
37. ATSC historical monograph, "History of the Control Function, ASC, 1942-1944," pp. 76-78.

supply of serviceable engines was made available, and overhaul schedules could be more accurately adjusted to actual needs.

Within the Air Service Command, increased attention was paid, especially after the reorganization of the command in December 1942, to the need for presenting current data on maintenance, supply, and other activities in readily assimilable form. For this purpose, each depot set up Maintenance Division (as well as Supply and Personnel and Training Division) Control Rooms. Here charts were displayed on such items as the number of propeller blades straightened during the previous month, and the input, output, and backlog of reparable engines. The control room at Headquarters, Air Service Command contained charts and graphs summarizing all depot and subdepot operations.[38]

Establishment and Publication of Maintenance Policy

The policies governing maintenance activities took shape in response to the information reaching Headquarters, AAF from the sources just described. The Maintenance Division at Wright Field prepared virtually all maintenance directives and published them in the form of Technical Orders or ATSC Regulations. Only a few of the directives written at Wright Field required coordination with Headquarters, AAF—namely those in which general policy changes were involved. Thus, the proposed consolidation of Forms No. 1 and 41B, although worked out at Wright Field, would require approval from Washington, and the same would be

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38. Ibid., pp. 114-16. See also Col. James G. Taylor, Control Officer, Hq., ASC, to all area air service commands, 22 Oct. 1942, in TSCHI-2 files, for the "Minimum Requirements Chart Program for Area Air Service Command Control Rooms."

true of any changes made in the inspection intervals for airplanes.[39] The process of coordination for such Technical Orders or other directives as were sent to Headquarters, AAF was as follows: a draft was submitted to the maintenance specialists in the Air Services Division of Materiel and Services for study. It was next forwarded with comments to the executive's office for Materiel and Services for further study and approval or disapproval. Sometimes coordination with other staff sections or with the Air Inspector was necessary before final action could be taken. High policy in such extraordinary matters as maintenance procedures for jet-propelled aircraft was frequently determined by the Air Staff itself, but routine maintenance decisions were normally made by the Air Services Division.[40]

The Materiel and Services office in Washington further decided upon the general outlines of the maintenance system of the AAF and such special problems as how maintenance of Other Arms and Services equipment should be performed. Decisions on such matters were published as AAF Regulations. Also, there were occasions on which Headquarters, AAF directed the Air Technical Service Command to write Technical Orders on particular subjects. Thus, TO No. 00-25-15, which made Technical Orders compliance optional on the part of an overseas theater commander, was prepared at Wright Field upon request from Washington.[41]

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39. Interview with H. E. Mayer, Chief, Methods Unit, Methods and Procedures Br., Maint. Control Sec., Maint. Div., Hq., ATSC, 18 May 1945.
40. Interview with Lt. Col. Clarence Haymes, Exec., AC/AS, M&S, 24 July 1945.
41. Interview with H. E. Mayer, 18 May 1945.

Basic Maintenance Policies

Fundamentally, the obligation of the Army air arm to accomplish maintenance of its own equipment was prescribed by Army Regulations.[42] A general outline of the manner in which the obligation was to be fulfilled was set forth by AAF Headquarters in Circulars and later in AAF Regulations. One important series of such regulations charged the Materiel Division (later the Air Service Command, and then the Air Technical Service Command) with command responsibility for depot maintenance and technical control of the lower echelons of maintenance performed by the flying units.[43] These responsibilities were administered, as already indicated, through the issuance of technical publications ranging from general directives defining the echelons of maintenance and listing the overhaul and repair activities at the depots to highly detailed instructions for performing a particular job.

Taken together, the above described directives may be said to constitute the AAF system of maintenance. Only the "policy" directives--those outlining (1) the Visual Inspection System, (2) Depot Repair and Overhaul, and (3) the Obsoletion Policy--are discussed in this chapter.[44]

The Visual Inspection System. Periodic maintenance inspections designed to detect signs of wear or failure in the aircraft or engine and to provide lubrication or other servicing and routine adjustments on a regular schedule formed the basis of the maintenance system. In

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42. "Supply and maintenance of all aeronautical equipment" is one of the duties charged to the Air Service in AR 95-5, 17 Nov. 1921, and in all subsequent regulations of that series.
43. AAF Regs. in the 20-1 series.
44. The actual performance of inspections and other maintenance work is described in Chap. V.

1939, the following inspections were prescribed: preflight, daily, 20-hour, 40-hour, 80-hour, weekly, and engine change. The performance of these inspections as well as of repairs that were made incident to the inspections was recorded on Form No. 41.[45] Such inspections and minor repairs were normally the responsibility of squadron personnel at the air bases.

In July 1941, the inspection intervals were lengthened because it had become apparent that airframes of modern all-metal construction required less frequent attention than the older wood-fabric and metal-fabric types. The 20-hour inspection was to be performed after 25 flying hours, the 40-hour inspection after 50 hours, and the 80-hour after 100 hours. The other inspections—preflight, daily, weekly, and engine change—were not altered. The preflight could not be omitted under any circumstances prior to a flight, but the daily routine was a less rigid requirement, although no airplane was to remain more than six days without an inspection. The 25-hour was to be accomplished between 20 and 30 hours and the 50-hour between 40 and 60 hours after the preceding 50-hour inspection. In other words, a 10 per cent departure from the terms of the directives was permitted. No airplane was to go without a 50-hour inspection for a period longer than 3 months. Transient airplanes flown by command or senior pilots were not to be grounded for routine inspections that might be due, without the pilot's approval.[46]

The outlines of the visual inspection were not changed significantly during the war, although several minor innovations should be noted.

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45. TO 00-20A, 1 Oct. 1938, revised 1 Feb. 1939; TO 00-20A-1, 4 April 1941; TO 00-20A-1, 7 June 1941.
46. TO 00-20A, 1 July 1941.

The provision that only senior or command pilots could secure an exceptional release for transient airplanes when an inspection was due was changed to give this privilege to any pilot.[47] More important was the appearance of Maintenance Instruction Forms, or inspection instructions in the form of check lists. The directions for the 25-hour, 50-hour, and the other inspections were printed on separate sheets, and there was a series of such instructions for each of several different airplane models. Heretofore, general directions applicable to all models of airplanes were provided in Form No. 41, and the inspector had to bear in mind the additional operations that a particular airplane required.[48] Consequently, the new forms, prepared for a specific airplane model and a specific inspection, were more convenient to use. In 1944, the inspection instructions were bound in pamphlet form and issued as Technical Orders under the title of Inspection and Maintenance Guide. There was a separate guide for each of the more important airplane models, and the check list of operations was supplemented with notes on procedures, a Technical Order index, an accessory equipment list, a special tool list, and diagrams of the airplane.[49] The inspection of airplanes for which no such guides were issued was conducted according to instructions included in the appropriate Erection and Maintenance Instruction Handbook, the manual provided for each airplane model usually by the contractor.[50]

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47. AAF Reg. 65-22, 22 Oct. 1943; AAF Reg. 65-22, 6 May 1944.
48. See Form 41, Part I, Figure 5.
49. Aircraft Inspection and Maintenance Guide for B-17 Series, TO 00-20A-2-B-17, 15 May 1945.
50. TO 00-20A-2, 1 Nov. 1944.

The proposal to alter the inspection intervals from the 20-, 40-, 80-hour to the 25-, 50-, 100-hour basis was initiated by the Inspection Division, OC/AC after some study had been given maintenance records. The concurrence of the Materiel Division was secured, and the change was thereafter made official.[51] During the war, there were several requests for further revisions. In particular, the Air Transport Command, apparently dissatisfied with the 25-, 50-, 100-hour schedule because it was considered too conservative in the light of Air Transport Command experience and because it required too frequent grounding of their airplanes, urged an extension of the intervals to 75 and 150 hours.[52] The Air Service Command refused this request on the grounds that it lacked the authority to allow such deviations in a policy formulated by the Air Inspector.[53] A later suggestion by the Second Air Force to the effect that inspections of certain items should be made more frequently than called for in the current schedule was referred to Headquarters, AAF by the Air Service Command with the recommendation that a service test of the proposed schedule be considered.[54] The conference held at Headquarters, ATSC on this subject in January 1945 has already been mentioned.

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51. R&R, Inspection Div. to C/AC through the Mat. Div., 9 Sep. 1940, in AAG 452.1-163, Inspection--Planes.
52. Maj. Donald W. Nyrop, Asst. Exec. ATC Opns., to CG, European Wing, etc., ATC, 2 May 1944, in TSAGD 452.09, Inspection of Aircraft and Aeronautical Equipment; Col. George D. Campbell, Jr., Dir. of Opns., Ferrying Div., ATC, to CG, ASC, 19 May 1944, in ibid.
53. 1st ind. (Col. George D. Campbell, Jr., Dir. of Opns., Ferrying Div., ATC, to CG, ASC, 19 May 1944), Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to CG, Ferrying Div., ATC, 19 June 1944, in ibid.
54. Lt. Col. W. C. Weaver, Asst. DC/S, 2d AF, to CG, ASC, 22 July 1944, in TSAGD 452.09, Inspection of Aircraft, General Frank's file (C).

Depot Inspection and Repair. The policy of assigning to the air depots the responsibility for major repair and overhaul of airplanes and engines in the continental United States was continued during the period 1939-1945, although, because of the immense volume of wartime work, a limited amount of equipment was overhauled by commercial contractors.[55] Late in 1944, the suggestion was made that the engine overhaul policy be altered to permit contracting such work to the manufacturers on a permanent basis. This policy, it was pointed out, would strengthen the aircraft engine industry during peacetime.[56] Suggestions such as this were not adopted, however, and were devoted to increasing both the productive capacity and the operating efficiency of the AAF air depots which, by 1944, were 12 in number.

The directives governing depot operations also set forth certain definitions and concepts that were fundamental to the AAF maintenance system. In particular, the echelons of maintenance were defined here. In directives dating back to 1936, "first echelon" was used to denote inspection, servicing, and minor repair accomplished by the flying organizations, and "second echelon" the heavier repair and replacement of unit assemblies by the station or base. The work performed at the depots was usually called "complete overhaul."[57] In a directive of 1940, however, three echelons of maintenance were distinguished, the term "third echelon" being applied to depot operations, which included all operations necessary for the restoration of damaged aircraft to a

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55. Contract overhaul is discussed in Chap. II.
56. Daily Activity Report to Gen. Arnold, AC/AS, OC&R, 30 Nov. 1944, in AFSHO files.
57. TO 00-25-4, 12 Dec. 1936; TO 00-25-4, 15 April 1937; TO 00-25-4, 19 Aug. 1938; TO 00-25-4, 18 Oct. 1939.

condition of tactical serviceability, for the major overhaul of engines, and for the fabrication of parts not otherwise available.[58]

In February 1942, the development of the subdepots required that provision be made for an additional echelon of maintenance. Consequently, the echelons were redefined as follows:[59]

> 1st echelon maintenance of the complete airplane is a function of all Air Corps units operating or maintaining aircraft. It includes the cleaning and servicing of airplanes and airplane equipment, the performance of periodic preventive inspections, and such adjustments, repairs, and replacements as may be accomplished by the use of hand tools and other mobile equipment authorized for issue to the unit. This includes engine change when the ground echelon of the organization concerned is at the site. . . . All essential tools and other equipment provided for the performance of first echelon of maintenance are transportable by air.
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> 2nd echelon of maintenance embraces repairs and replacements requiring mobile machinery and other equipment of such weight and bulk that ground means of transport is necessary. Units charged with this echelon of maintenance require specialized mechanics. This echelon includes field repairs and salvage, removal and replacement of unit assemblies, fabrication of minor parts and minor repairs to aircraft structures and equipment. Normally, this echelon embraces repairs which can be completed within a limited time period, this period to be determined by the situation prevailing.
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> 3rd echelon of maintenance is a function of sub-depots. It includes repairs and replacements requiring fixed machinery and tools; parts and equipment not carried by operating units or materiel squadrons in the field; the recovery, reclamation or repair and return to service of aircraft incapable of flight when, due to location or other causes, this action is more economical than its accomplishment by 2nd echelon facilities; and such operations normally performed by air depots as may be authorized and for which the necessary personnel and facilities are available, including repairs requiring temporary withdrawal of aircraft from tactical use but not warranting or necessitating return to the air depot.

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58. TO 00-25-4, 13 Nov. 1940.
59. TO 00-25-4, 14 Feb. 1942.

> 4th echelon is a function of the depot and depot group. It includes all operations necessary to completely restore worn or damaged aircraft to a condition of tactical serviceability and the periodic major overhaul of engines, unit assemblies and auxiliary equipment; the fabrication of such parts as may be required in an emergency or as directed in technical instructions; the accomplishment of technical compliance changes as directed; or replacement, repair and service checking of auxiliary equipment; and the recovery, reclamation or repair and return to service of aircraft incapable of flight.

Later in the same year, it was acknowledged that sharp distinctions between the echelons of maintenance were neither necessary nor desirable. The amount and the kind of work to be accomplished by each echelon was to be limited primarily by the available equipment and supplies, and the experience and initiative of the personnel.[60]

The directives on depot maintenance cited above also set up standards to assist the operating units to determine when airplanes and engines should be sent to the depots for overhaul. So far as airplanes were concerned, the policy was that they were to be grounded for complete depot reconditioning only when inspections revealed the need for repair beyond the capacity of the lower echelons and not merely because a certain predetermined period of service had elapsed.[61] Nevertheless, as a guide to operating units the same Technical Orders listed what was regarded as the normal number of flying hours and the normal elapsed time in months between overhauls for each of the more important models

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60. TO 00-25-4, 19 Dec. 1942.
61. This policy was worded substantially as follows in all the TO's of the 00-25-4 series from 1936 to 1945: "Air Corps airplanes will not be grounded for complete depot reconditioning due to fair wear and tear merely on the basis of the expiration of predetermined periods of age or service, but only for good and sufficient reasons indicated by the general condition of the equipment." TO 00-25-4, 12 Dec. 1936.

of aircraft. These figures tended to rise as more experience with the endurance characteristics of all-metal aircraft structures was accumulated. In 1940, for example, the suggested inter-overhaul time for the B-17 was 4,000 flying hours, or 30 to 60 months of service,[62] but by 1944, the time had been increased to 8,000 flying hours, or 84 months of use.[63] It should be observed, however, that most other airplanes were not considered so durable.

For engines, the inter-overhaul time was much more critical. During most of the period 1939-1945, the flying hours listed for each engine in the Technical Orders were theoretically[64] not to be exceeded more than 20 per cent, and then only if the condition of the engine warranted.[65] Late in 1943, this policy was relaxed and longer extensions authorized, provided strict attention was paid to oil consumption and other evidences of wear as the engine approached its specified period of use.[66] Also, the inter-overhaul time given for most engines tended to increase. In 1939, for example, the several different series of the R-1820 were allowed from 300 to 375 hours between overhauls,[67] but by 1945, 500 to 650 hours were permitted.[68] These increases were a direct result of improved design, materials, and fuels.

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62. The commander of the tactical organization to which the airplane was assigned was allowed some latitude in determining when the airplane should be overhauled. TO 00-25-4, 13 Nov. 1940.
63. TO 00-25-4, 16 Feb. 1944.
64. Statistics on actual inter-overhaul time as contrasted with prescribed limits are given in Chap. VI.
65. TO 00-25-4, 18 Oct. 1939. Prior to 1939, however, the extension permitted was only 10 per cent. TO 00-25-4, 19 Aug. 1938.
66. TO 00-25-4, 13 Nov. 1943.
67. TO 00-25-4, 18 Nov. 1939.
68. TO 00-25-4, 1 April 1945.

Another phase of the engine overhaul policy was that the installed engines on airplanes sent in for depot inspection and repair (DIR) were to be changed and sent to the overhaul shops if 80 per cent or more of their specified inter-overhaul time had been accumulated. Otherwise the engines were not to be changed unless in poor condition, although minor repairs were permitted.[69] In 1945, however, the older plan of replacing such engines when only 60 per cent of their allotted time had been accrued was restored.[70]

Closely related to the problem of when equipment should be sent to the depots for overhaul was the policy of economical repair. Such a policy was in effect in 1939. Tables were prepared by means of which the feasibility of returning a damaged aircraft to a serviceable condition could be determined. During the war, less attention could be paid this matter by depot personnel, although tables of allowable repair costs were still issued.[71] In general, the decision to repair or to survey a damaged airplane depended not so much upon the costs as upon the tactical demand for that particular model and series of airplane, the time necessary for the work, the availability of the necessary parts, and such other considerations as whether the aircraft shops could do the work without serious interruption of projects already in hand.[72] In 1944, however, a new method was prescribed for determining the "repair status" of a damaged airplane. The number of direct man-hours necessary

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69. TO 00-25-4, 18 Oct. 1939.
70. TO 00-25-4, 1 April 1945.
71. "Table for Computing Allowable Airplane Repair Costs," Budget Office, Mat. Comd., 1 April 1942, in TSCHI-2 files.
72. Interview with E. F. Boger, Gen. Supt., Maint. Div., FATSC, 10 Sep. 1945.

to return the airplane to service were to be estimated and this figure compared with the allowable man-hour expenditure with adjustments for the age, model, and series of the airplane concerned. If the number of man-hours required for repair proved to be beyond the allowable maximum, the airplane was to be processed as excess.[73]

The Obsoletion Policy.[74] The procedure for declaring aircraft and equipment to be obsolete and retiring them from service obviously had an important bearing on maintenance policy. Early in 1939 aircraft were allowed a total life of 10 years, but the various combat types were declared obsolete after six to eight years of service. This long a legal life for airplanes was ascribed not so much to the superior endurance of all-metal construction as to improved maintenance methods and to the need for retaining enough airplanes in service to supply Air Corps requirements.[75] The setting of a definite project life for each model of aircraft by the War Department was later dropped, however, and recommendations to declare equipment obsolete were thereafter made by the AAF whenever "the development and availability of new types should make such action desirable."[76] In February 1945 the Commanding General, AAF was empowered to make the final decision to render items of equipment obsolete.[77] Recommendations as to obsoletion or to other

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73. AAF Reg 65-87, 16 Aug. 1944.
74. The present discussion of obsoletion is brief inasmuch as this subject is to be given a fuller treatment in a contemplated monograph on salvage and disposal.
75. Interoffice memo, Chief, Fld Serv. Sec., Mat. Div., 8 Nov. 1939, in TSBFO 000.01, Airplane Age.
76. AR 850-25, 30 June 1943, Sec. II, par. 14b and 18; AAF Reg. 65-72, 30 Nov. 1943.
77. AR 850-25, c. 4, 9 Feb. 1945.

changes in the status of AAF equipment were prepared by the Specifications Branch of the Engineering Division, ATSC and forwarded to Headquarters, AAF for the approval or disapproval of the Assistant Chief of Air Staff for Operations, Commitments, and Requirements.[78]

In order to keep all activities of the Army Air Forces informed about the rapid changes in the classification of equipment as obsolete or otherwise, a publication, The Status of Equipment, was issued at frequent intervals by the Air Technical Service Command. Here, AAF equipment was listed alphabetically and by model designation, and the current classification (obsolete, standard, etc.) and the date of such classification were given. The official definitions of the various classifications of equipment were also supplied. Obsolete articles were defined as those which had been declared unsuitable for their original military purpose. In addition, there were three classifications of developmental equipment—experimental, service test, and limited procurement types; and three types of adopted equipment—standard, substitute, and limited standard.[79]

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78. Interview with Eve Kuchesky, Chief, Standards and Specifications Sec., Eng. Br., AC/AS, M&S, 25 July 1945.
79. Status of Equipment, June 1945.

Chapter V

MAINTENANCE PROCEDURES

The discussion of maintenance procedures includes descriptions of the actual performance of inspections and of the several echelons of repair. An account of the sort of work falling under the first three echelons of maintenance is incorporated in the summary of maintenance inspections, inasmuch as such operations were commonly performed incidentally to the routine inspections. The fourth echelon airplane and engine overhaul activities at the depots are described separately, however. For purposes of illustration, the inspection and overhaul procedures applying specifically to the B-17 airplane and the R-1820 engine, which powered the B-17, are followed through. In addition, certain maintenance developments like the production-line system of conducting inspections, progressive overhaul, specialization, and modification are considered briefly.

Inspection and Repair Procedures

The preflight, daily, and 25-hour inspections were usually conducted out of doors on the flight line by squadron personnel working under the supervision of the crew chief of the airplane. In addition to inspections, the line crew was also responsible for servicing the airplane with fuel and oil, pulling the chocks, walking the wings during taxiing, and making minor adjustments and replacements. For B-17

airplanes, the appropriate Aircraft Inspection and Maintenance Guide provided a much more convenient list of the operations to be accomplished than did the Erection and Maintenance Instruction Handbook or Form No. 41B.

The preflight inspection given prior to the first flight of the day was distinct from the daily inspection. In all, more than 100 separate items were to be checked before the airplane could be released for flight. These operations may be grouped as follows:[1]

1. Data Case. The Flight Report, Forms No. 1 and 1A, was examined for completeness and for ascertaining whether any routine inspections were due. Also, the Data Case was checked for its full complement of flight and operating instructions and Radio Facility Charts.

2. Fuel and Oil. The fuel and oil levels were checked and the cells inspected for evidence of leaks or deterioration. If refueling were necessary, the airplane was provided with a static ground.

3. Turbosuperchargers. The supply of turbosupercharger lubricating oil was checked, the air scoop examined for obstructions, and the bucket wheels spun by hand to test freedom of rotation.

4. Landing Gear. The main landing gear and the tail wheel gear, including tires, rims, retaining bolts, and the like, were examined for obvious defects. Also, the tires and struts were properly inflated, the hydraulic fluid level checked, and the brakes tested.

5. Pitot tubes. The air speed head protectors were removed and the openings checked for freedom from obstructions.

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1. TO AN 01-20EG-2, 25 Aug. 1944, revised 15 Feb. 1945, pp. 441-60, and TO 00-20A-2-B-17, 15 May 1944. These two directives differ slightly in details of the preflight inspection.

6. Fire Extinguishers. Both the engine and the hand fire extinguishers were inspected for full charge.

7. De-Icer and Anti-Icer System. De-icer shoes were examined for punctures and freedom from engine oil, and propeller anti-icers were checked for level of fluid. The windshield wipers and their supply of anti-icing fluid were also inspected.

8. Surfaces. The operation of the trim tabs was tested for excessive play. Further, the wings, ailerons, elevators, rudder, and stabilizers were examined for dents or punctures, and the cowling and inspection doors and covers tested for security.

9. Oxygen System. Oxygen pressure was tested at each crew position, and the tanks were charged if necessary.

10. Hydraulic System. The level of the fluid supply was checked as was the operation of the accumulator pump.

11. Cockpits and Cabin. The windshield and windows were cleaned and damaged plexiglass replaced; doors and sliding enclosures were tested for proper functioning; and safety belts, seats, and first-aid kits were checked.

12. Instruments. Broken and loose cover glasses on the instrument panel were replaced, and the free air thermometer and altimeter were checked. Lamps and fuses were also replaced when necessary.

13. Engine Warm-Up. The engines, having been started one at a time to avoid overloading the batteries, were run up to not more than 2,000 r.p.m. while the oil pressure, oil temperature, and fuel pressure gauges were checked. The flight and turn indicators were also checked.

14. Ignition and Electrical Equipment. The engines were each operated on one magneto and the consequent drop in r.p.m. (not to exceed 100 r.p.m.) was noted.

15. Propellers and Accessories. Propeller pitch controls were operated to test full range.

16. Communications Equipment. The interphone and the various radio equipments, including the command and liaison sets, the radio compass, and the marker beacon receiver were tested.

17. Miscellaneous: Depending upon the sort of mission for which the airplane was being prepared, there were additional inspections of life rafts, bombing, gunnery, and photographic equipment.

The daily inspection given the B-17 consisted essentially of the same operations as those described above, with the addition of the following steps:[2]

1. Cowling. The engine cowling was removed and inspected for security of fasteners and for evidence that the engines were throwing oil. Also, the exposed portions of the engines and of the engine mounts were checked for loose nuts.

2. Engine Controls. The throttle, mixture, and intercooler control assemblies were examined for proper functioning.

3. Turbosuperchargers. The buckets were examined for nicks, dents, or gouges.

4. Air Filters. The carburetor air filters were inspected for proper lubrication and dirt.

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2. TO AN 01-20EG-2, 25 Aug. 1944, revised 15 Feb. 1945, pp. 461-68; TO 00-20A-2-B-17, 15 May 1944.

5. Fuel and Oil Systems. Fuel and oil lines were inspected for leaks, and the pump mountings were tested.

6. Electrical and Ignition System. Starters, generators, switches, and solenoids were checked for proper operation and security of mounting.

7. Landing Gear. Both the main and tail landing gears were examined for proper alignment.

8. Hydraulic System. Hydraulically operated units were inspected for leaks and repacked when necessary.

9. Communications Equipment. Antennas, mountings, cordage, and filter boxes were tested.

10. Anti-Icers. This equipment was to be operated daily to prevent corrosion.

11. Fuselage and Surfaces. The skin of the airplane was inspected for tears, dents, and distortions that might be the result of broken structural members.

12. Heating and Ventilating System. This equipment was checked for proper functioning.

13. Batteries. Each of the three 24-volt batteries was checked by hydrometer readings of at least two cells, and any corrosion at the cable terminals was removed.

The 25-hour inspection, sometimes given as often as once a week, depending on the amount of good flying weather, consisted of about 50 per cent more operations than either the preflight or daily inspections, and many of these required removal of access doors or some disassembly.

The principal items peculiar to the 25-hour inspection were as follows:[3]

1. Batteries. All battery cells were tested by hydrometer readings, and batteries showing a low charge were replaced. The mounting bolts were also checked.

2. Fuel Cells. These were inspected for leaks, proper paddings, and strap tension.

3. Engines and Nacelles. A general inspection was made for leaks and for failure of any parts. The spark plugs were removed for resetting the gaps and were then reinstalled. The magnetic sump was examined for particles and the cuno oil filter inspected. The cowl flaps and flap control mechanism were lubricated.

4. Fuselage and Surfaces. A check was made for cracks, checks, and loose rivets. The hinges and pins on movable surfaces were inspected for general condition.

5. Landing Gear. The retracting mechanism was examined for cracks, bends, and elongated bolt holes, and the brakes were inspected for leakage.

6. Flight Controls. Rudder pedal assemblies and all exposed universals were lubricated, and the control columns, linkage, and fittings were checked for proper operation.

The 50-hour inspection, commonly given in a hangar, and at some fields performed on a production-line basis, repeated the 25-hour procedure and included, in addition, about 50 new items. The most important of these were inspections of such structural features as wing joint

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3. Ibid.

terminals, attachment plates, flanges, and chordwise stiffeners. Wrinkled skin, elongated bolt holes, and pulled rivets were considered possible evidence of structural failure that required investigation. Also, the landing gear was retracted and lowered both electrically and by hand, and, at the same time, inspected for any faults. Further, the propeller blades were examined for nicks and coated with clean engine oil, and propeller mechanisms were tested.[4]

The 100-hour inspection, also conducted in the hangar, involved considerably more disassembly than the 50-hour check. For example, the propeller domes were disassembled for cleaning and lubrication of internal parts, and the wheels were removed to permit inspection of the brake drums for scoring. In addition, all spark plugs were changed, control cable tension was checked and corrected, and life rafts were taken out for a complete check. Certain accessories, like the auto pilot and bombsight, also received some attention at 100 hours.[5]

The repairs that were found necessary in one of the routine inspections, if they consisted merely of minor adjustments or replacements, were performed at once by the inspecting personnel. Otherwise, the airplane was sent to the air base hangar, the subdepot, or even the air depot, depending on what echelon of work was deemed necessary to restore it to serviceable condition. The visual inspection system did not always work so smoothly as the above description implies, however. Mention has already been made of the complaints of subdepot and depot

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4. TO AN 01-20EG-2, 25 Aug. 1944, revised 15 Feb. 1945, pp. 469-513; TO 00-20A-2-B-17, 15 May 1944.
5. Ibid.

commanders to the effect that too frequently flying organizations were forwarding airplanes on which first and second echelon maintenance had been neglected and which were due or overdue for 50- or 100-hour inspections.[6] There were also occasions on which squadron or subdepot personnel attempted to perform higher echelon work than their authorization permitted. In general, however, the tendency was for the lower echelon to pass along to the next higher echelon repair work that it could have accomplished.

At many bases during the last months of 1942 and later, the 50- and 100-hour inspections came to be performed on the production-line maintenance system, often called PLM. This system, first used at Gunter Field, Ala., in the summer of 1942, then tested and developed by the West Coast Training Center in the fall of the same year, involved routing the airplane through a number of stations at each of which specialized mechanics made the prescribed inspections and any repairs or replacements found to be necessary.[7] In place of a crew leader and a number of assistants for each airplane, a large group of men divided into specialist teams was assigned to conduct the inspections for all airplanes at the air base. The procedure, generally speaking, was as follows. The airplane was first steam-cleaned and the cowling and inspection plates were removed. A preliminary inspection was then made to determine what repair work was necessary. If third or fourth

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6. See Chap. III, Subdepot Control.
7. Contract overhaul agencies had been using specialized inspection crews which moved from airplane to airplane as early as 1941, but the production-line system in which the airplane itself was moved through the line appears to have been an AAF development. "History of the Western Flying Training Command, Installment III, 1 January-31 December 1943," p. 738.

echelon repairs or replacements were indicated, the airplane was taken out of the PIM line and sent to the Shop Maintenance and Engineering Unit (subdepot) or to the depot. Otherwise, the airplane in its turn was moved to Station 1 in the production line, which was sometimes set up in a hangar or a specially designed building at other bases on the mooring apron. Here, fuel tanks and fuel lines inspections and replacements were made, and the wings and skin checked for breaks and dents. At station 2, control mechanisms and electrical equipment and wiring were inspected and, when necessary, repaired. Station 3 was given over to minor engine work; Station 4 to Technical Order compliances and to cleaning the interior of the airplane; Station 5 to landing gear maintenance; and Station 6 to final inspection and recowling. The airplane was then sent to the flight line for a preflight inspection.[8] Under this system, it was estimated that the 100-hour inspection of a single-engine trainer, together with the normal, incidental repairs, could be completed in two and one-half hours, a considerable saving over the older method.[9] The development of the various stations making up the PIM line was, of course, a process of trial and error.

The use of PIM spread very rapidly, the principal reasons being a rapid increase during 1942 and 1943 of the number of aircraft assigned each air base, a lower experience level on the part of mechanics, and a shrinking ratio of mechanics per airplane. Late in 1942, the western basic and advanced flying schools were directed to install PIM as soon

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8. Ibid., pp. 740-42.
9. Maj. Oliver King, Tech. Supervisor, to CG, West Coast Training Center, 20 Aug.1942, in AAG 400.4, Using, Wearing, etc., Methods of Equipping.

as possible,[10] and its use became general at flying schools elsewhere in the country during 1943. That PIM was an excellent answer to the problems involved in a constantly increasing work load is attested by the experience of the Western Flying Training Command. At the bases of that command during the year beginning February 1943, the number of assigned airplanes, training and tactical, increased from 5,840 to 8,870, or approximately 50 per cent. At the same time, the number of enlisted men in the school squadrons was reduced from a ratio of nearly 11 men per airplane in service, including maintenance, supply, and miscellaneous personnel, to less than seven per airplane. Nevertheless, because of the use of PIM, the airplanes were kept in better condition than ever before, and the over-all proportion of airplanes in commission rose steadily to approximately 80 per cent.[11] In December 1943, the Air Service Command estimated that the increase in the number of serviceable aircraft at a typical base after the introduction of PIM was 25 per cent.[12]

Early in 1944, it was found that even the 25-hour inspections could be more efficiently performed on a production line, and many bases adopted this extension of the PIM system.[13] Also, PIM methods, which

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10. Maj. T. R. Hornaday, Asst. AG, West Coast Training Center, to CO's, all basic and advanced flying schools, 7 Nov. 1942, in AAG 452.031, Miscellaneous Maintenance and Repair.
11. "History of the Western Flying Training Command, Installment III, 1 January-31 December 1943," p. 763.
12. 1st ind. (Maj. J. P. Goode, Acting Asst. AG, Training Comd, to CG, ASC, 2 Dec. 1943), Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to CG, Training Comd., 9 Dec. 1943, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.
13. "History of the Western Flying Training Command, Installment IV, 1 January-30 June 1944," p. 499.

had heretofore been used almost altogether on trainers, were developed for tactical airplanes, such as P-40's, B-17's, B-24's, and B-25's. Some special equipment was necessary to put tactical models on a moving production line, whereas very little was required for trainers. Nevertheless, the experiment was successful at a number of bases where facilities were installed.[14] PLM methods were even worked out for combat groups in 1944.[15] Another feature of PLM was its adaptability to training purposes, since trainees could be kept at one simple operation at a station in the line until they had learned it and then rotated to another operation. The Training Command in particular made use of the production-line inspection system for training mechanics.[16]

Overhaul Procedures

Depot Inspection and Repair of Airplanes (B-17). When an airplane was considered by the crew chief and the organization engineering officer to be in need of fourth echelon work because of advanced wear or damage, it was sent to the depot in the same control area as the

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14. "History of the Western Flying Training Command, Installment III, 1 January-31 December 1943," pp. 760-63. The Air Service Command, early in 1943, announced that the additional facilities necessary for PLM were at least temporarily unavailable, but directed the subdepots to furnish supplies and facilities for PLM to the air bases as best they could. Memo report, Lt. Col. E. W. A. Taylor, Acting AG, SAADCAC, 17 Feb. 1943, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment; TWX ASCSD-5-1, CG, ASC to CG, SAADCAC, 6 May 1943, in ibid.
15. Production Line Maintenance Manual for Combat Groups, published as Maint. Div. Circular 28, 15 Feb. 1944, by the Air Serv. Comd. In "Maintenance Division Annual Report, 1944," Exhibit A, in TSCHI-2 files.
16. Memo report, Lt. Forry W. Norton, Asst. PLM Officer, Pecor Army Air Fld., 1943, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.

air base to which it was assigned or to the depot specializing in the Depot Inspection and Repair (DIR) of that model.[17] During the war, a large block of airplanes of the same model would often be found to require depot reconditioning at about the same time. In such a situation, the air force or command flying the airplanes usually made arrangements with the appropriate depot and the Air Service Command for scheduling an orderly flow of work into the depot shops.[18] Again, "war weary" airplanes were frequently returned from overseas theaters in a group and were ordered to one of the depots for DIR.

In keeping with the work schedule, each airplane to be reconditioned was ferried to the depot. Upon arrival, the pilot relinquished Form No. 41B and the auxiliary maintenance records[19] and signed his airplane over to the Aircraft Receiving and Delivery Branch. This unit thereupon notified the Aircraft Repair Section and other depot activities of the arrival of the airplane and prepared it for work by removing and storing all loose equipment and sending the maintenance records to the Production Inspection Section for examination. In order to determine in general what work was required, Production Inspection then gave the airplane a visual inspection, in the course of which the engines were

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17. For the form of the request for depot work, see TM 1-650, 8 June 1942, par. 31.
18. For example, the Air Technical Service Command directed the San Antonio depot to prepare for the DIR of 125 to 150 P-47's belonging to the Second Air Force. The scheduling of the airplanes was to be arranged directly with the Second Air Force. Col. Albert V. Endress, Acting Chief, Control Sec., Maint. Div., ATSC, to CG, SAATSC, 5 Dec. 1944, in TSAGD 452.09, Inspection of Aircraft and Aeronautical Equipment.
19. Forms 60 and 60A, Technical Order Compliance Records; Form 61, Propeller Historical Record.

run up and tested for compression and the fuel cells filled and examined for leaks. The engines were then drained, removed from the airplane,[20] and "pickled"—that is, treated against corrosion and placed in stock.[21] The batteries were removed at the same time. A list of necessary repair items and TO changes required by the airplane was sent to Production Control by the Production Inspection Section, and from this material a work book was compiled. All work subsequently performed on the airplane was checked against this book.

The airplane was next towed to the apron of the aircraft repair building for the first stage of the reconditioning process, usually known as Station 0.[22] At Station 0, all armament and the four propellers were tagged and sent to specialized shops for inspection, performance of any Technical Order changes that might be pending, and overhaul. All inspection plates were also removed and the airplane was steam-cleaned and washed.

At Station 1, normally the first station inside the hangar, personnel from eight different departments worked on the airplane, each department being assigned a different section or area of the airplane to avoid confusion. At the Fairfield Air Depot, the exact operations to be performed at this and at every subsequent station were described

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20. The engines were removed from approximately 90 per cent of the airplanes sent in for reconditioning whether or not new or overhauled engines were to be installed.
21. Silica gel bags were placed in the engine to absorb moisture and the spark plugs were replaced by other moisture-absorbing devices.
22. From this point to the flight test, the procedures described here are those developed specifically for the B-17 and used at Fairfield and elsewhere.

briefly on a chart affixed to the station captain's desk (see Figure 6). As may be seen from the Station 1 chart, the Airplane Assembly Department, among other things, repaired the firewalls in the nacelles, removed bomb bay and flap-actuating motors, and performed other work indicated in the work book. At the same time, the engine crew was to remove turbosuperchargers needing repair, the Radio Department was to take out all radio equipment, and other departments were to perform other tasks. In general, it may be seen that disassembly was the principal responsibility of Station 0 and 1.

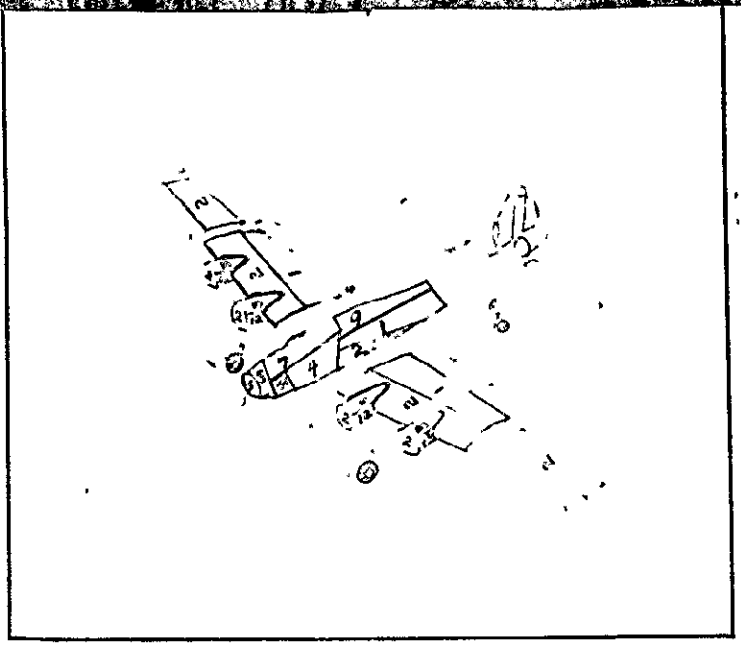
The duties assigned to Station 2 were largely concerned with the wings, nacelles, and the control surfaces. The Airplane Assembly Department inspected and repaired aileron control rods and hinge brackets, installed the wing flap motor, lubricated the aileron, flap, and rudder hinge bearings, and replaced engine control rods, bearings, and bell-cranks in the nacelles. The Sheet Metal Department completed inspections and repairs in the fuel cell cavities of the wings. The Electrical and Radio Departments made certain installations and modifications, and the engine crew installed serviceable turbosuperchargers, if needed, and completed all firewall work.

Station 2A was given over to the installation of serviceable engines. This process included the marking of fuel, oil, and coolant lines in conformity with the latest TO's, the replacing of faulty parts, and making all engine control and electrical connections. Detailed instructions for this work were set forth in directives to which reference was made on the station chart.

At Station 3, the fuel cells were tested, the fuel lines in the wings marked, and the cells installed and connected by the Airplane

DEPOT INSPECTION AND REPAIR OF B-17

STATION 1



1. AIRPLANE ASSEMBLY DEPARTMENT
2. [illegible] DEPARTMENT
3. [illegible] DEPARTMENT
4. [illegible] DEPARTMENT
5. [illegible] DEPARTMENT
6. [illegible] DEPARTMENT
7. [illegible] DEPARTMENT
8. ARMAMENT DEPARTMENT
9. FABRIC DEPARTMENT
10. LANDING GEAR DEPT.
11. ENGINE DEPARTMENT
12. RADIO DEPARTMENT
13. PAINT & DOPE DEPT.
14. INSPECTION DEPARTMENT

STATION NO. 1

(STATION 1) INTAKE SIDE - LEADING TO TRAILING EDGE

1. AIRPLANE ASSEMBLY DEPARTMENT

a. T.O. 01-20E-101 Firewall repair

b. T.O. 01-1-1.3 Installation of static ground.

c. T.O. 01-20F-16 Replacement of tail gunner's seat front hinge.

d. Replace or repair all bearings, rods and bellcranks that are a part of 1, 2, 3 and 4 engine controls.

e. Check clearance between fuel line and air cooler temperature control valve lever.

f. Install cover plate over nose seat, tie down hole to prevent dirt falling through to belly of airplane.

g. Inspect stress plates and route for repairs if required.

h. Complete all items in tail gunner's compartment (aft of Station 9).

i. Remove bombay door operating motor.

j. Remove wing flap motor in left inboard wing.

k. Complete all shakedown repair items applicable in areas assigned to this Station.

2. SHEET METAL DEPARTMENT

a. T.O. 01-20-44 Install reinforcing clips at leading edge of inner panel and 01-20E-101A.

b. T.O. 01-20-31 Making a new hole for landing gear equipment.

c. T.O. 01-20E-101 Elim. old holes and provide angles and drill holes for new vibrator.

d. T.O. 01-20E-1 (dated September 1943) Inspection and replacement of rudder lower hinge fitting rivets.

e. Completing all items on firewalls

f. Complete all shakedown repair items applicable in areas assigned to this Station.

3. ARMAMENT DEPARTMENT

a. T.O. 01-1-164 Restricting the use of Westinghouse Finger Type Voltage Regulator from Tactical Aircraft.

b. T.O. 01-1-170 Removal of circuit breaker from Airplane Generator System.

c. T.O. 01-1-43 Replacement of plunger assembly in oil and primer solenoids.

d. T.O. 01-1-68 Inspection of all electrical wiring, connector plugs and junction boxes (as applicable to work being completed at Station 1).

4. RADIO DEPARTMENT

a. Remove all radio equipment.

5. INSTRUMENT DEPARTMENT

a. T.O. 01-20FF-20 (9 May 1943) Installation of Autosyn Transmitter Covers on 1, 2, 3 and 4 engines.

b. Change lord mounts on Autosyn Instruments forward of firewall where necessary.

c. Complete all shakedown repair items applicable in areas assigned to this Station.

6. PLEXIGLAS DEPARTMENT

a. Give special attention to weather stripping around windows.

b. Installation of plexiglas.

c. Complete all shakedown repair items applicable in areas assigned to this Station.

7. ENGINE CREW

a. Prepare firewalls on 1, 2, 3 and 4 nacelles to receive engine connection. (Refer to Engine Breakdown Book for detailed directives).

b. Remove turbo superchargers when necessary. (Refer to Engine Breakdown Book for detailed directives).

8. FABRIC DEPARTMENT

a. Replace worn or torn floor matting.

NOTE 1: Work on the above shall be performed on an overhaul basis, and all associated work and technical orders shall be completed.

FIGURE 6

Assembly Department. The sane crew installed wing flaps, rudder, left wing tip, bomb-bay doors, outer wing panels, and leading edges. The Sheet Metal Department reworked aileron hinge brackets and reenforced the wing walkways, the Paint and Dope Department repainted the insignia, and the Armament and Bombsight Department installed both the top and the ball turrets. Similar installations were continued at Station 4, including trailing edge fairings, right wing tip, and fuel cell stress plates. In addition, all exposed control cables were treated with rust preventive, various electrical and radio modifications were accomplished, and the repair items in the work book pertaining to the bomb bay were accomplished.

All work in the engine nacelles, except landing gear repair, was to be completed at Station 5. Further, the de-icer boots were replaced, and repair and modification performed on the auto-pilot and bombsight. All fabric work, including upholstery and control surfaces which were to be re-covered and doped, was likewise to be finished. At Station 6, all work in the radio compartment was signed off the work book. In addition, the running lamps were water-proofed and aircraft instruments marked. All work items in the pilot's and waist gunners' compartments were to be signed off at Station 7. Here the flooring and such items as plexiglass and oxygen outlets were checked. The work in the nose and the tunnel was finished at Station 8, and, in addition, the landing gear, wheels, and tires were thoroughly tested and inspected after required replacements and modifications had been made.

At Station 9, bomb-bay fuel tanks, pilot's and copilot's seats, landing gear fairing, and nacelle covers were installed, and the Paint and Dope Department replaced illegible or missing decals and stencils

that were prescribed, and painted the control surfaces. The airplane was also cleaned, inside and out. Final inspection took place at Station 10, particular attention being paid to compliance with all TO's. At this point also, Production Inspection made entries on Forms 1 and 1A to the effect that the DIR was completed and delivered the form to the Flight Test Section.

The reconditioned airplane was then towed to the flight test hangar, where a shake-down inspection was conducted. The airplane was serviced with gasoline, oil, and hydraulic fluid, and the struts and supercharger oil reservoir were filled. The crew chief assigned to the airplane by Flight Test Branch then checked Form No. 1A to see whether the engines were newly overhauled, inasmuch as the starting procedure for such engines involved pre-oiling and spraying the cylinders. The fuel system was tested for leaks with the booster pumps operating, and then the engines were started and run up. Next, hydraulic pressures, propellers, supercharger regulators, and all engine controls were tested through their entire range of operation. The electrical and radio installations were tested by specialists and still other inspectors examined the control surfaces, cables, pedals, control columns, wheels, tires, landing gear, and struts. Any discrepancies discovered in the shake-down were usually corrected by flight test personnel. The airplane was then given a standard preflight inspection and finally was flown by the test pilot for approximately six hours.[23] The crew chief

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23. In accordance with a directive of August 1945, whether an airplane was to be test-flown depended on whether engine or control surface work that could be expected to affect the flying characteristics had been performed. ATSC Letter 66-13, 31 Aug. 1945.

who supervised the shake-down inspection also made the flight as engineer. He checked all instrument readings and made notes of any adjustments he considered necessary. The pilot was thus left free to observe the flying characteristics of the airplane at various speeds and altitudes and during a number of prescribed maneuvers.[24]

When the final adjustments recommended by the test pilot and crew chief were completed, the airplane was loaded with its loose equipment by the Receiving and Delivery Branch, and releases were secured from the various sections of the depot which had performed the work. The airplane was then signed over to Base Operations, and a crew was requested. After the crew's arrival, the Armament and Flight Test Branches installed any confidential equipment, and the airplane was signed out to the ferry pilot for return to its home base.

The length of time required for the processing of the airplane through the depot for reconditioning varied from two or three weeks to that many months, depending on the amount and kind of work to be performed and the availability of parts. During 1944, when the depots were at the peak of their productivity, airplanes were frequently in work in the aircraft repair hangar no more than two weeks, since they remained at each of the 12 stations approximately one day. The process described above for the B-17 airplane also applied, with some exceptions, to the DIR of other heavy bombers like the B-24.[25] The reconditioning

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24. TO 30-50A-1, 30 Sep. 1943. Interview with V. O. Knox, General Foreman, Flight Test Sec., FATSC, 10 July 1945.
25. See report by Col. M. E. Tillery, "Production Line on B-24 Airplanes as Operated at Ogden Air Service Command," in "Report of Maintenance Division Conference, Mobile Air Service Command, 20-21 Dec. 1943," in TSCHI-2 files. At Ogden, a B-24, The Virgin II, was in work for a DIR less than one month; and The Blue Streak was completed in only three weeks. "History of the Ogden Air Service Command, 1 January 1939 to 1 February 1943," p. 23.

of smaller tactical and of trainer airplanes was correspondingly less complex and prolonged a process.

Engine Overhaul (R-1820). The procedures developed for the overhaul of radial engines like the R-1820 (Wright Cyclone), with which the B-17 was equipped, are presented here, although many of these procedures applied to the overhaul of in-line engines as well. Successive models of the R-1820 engine were improved until in 1941 the R-1820-65 model, rated at 1,000 horsepower, was produced.[26] Still more improvements followed, and the R-1820-97, used on the B-17G, had a rated output of 1,200 horsepower. It is to this model that the specific overhaul procedures described below apply.

During the 1930's there was some degree of specialization in the depot overhaul shops. The skilled engine mechanics were assigned to various specific units, such as disassembly and cleaning, inspection, and subassembly. Thus an engine in the process of overhaul was transported from one unit to the next, where it remained while the necessary work was performed.[27] The huge overhaul requirements of the war, and the fact that only unskilled labor including women was available, however, made the adoption of advanced production-line methods imperative. Maj. Gen. Clements McMullen wrote in August 1943: "It is believed necessary to change to advanced line production methods in order to produce satisfactory overhauled engines in the AAF shops with the class

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26. "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," p. 50.
27. Ibid., pp. 47-48.

of labor available."[28] A few months thereafter, a progressive overhaul layout was installed at the Fairfield Air Depot with the assistance of engineers loaned by the Chevrolet Division of the General Motors Corporation.[29] In fact, the history of engine overhaul during the war years is concerned in large part with the installation of progressive overhaul lines in the depot shops.

The principal stages of overhaul for the R-1820 as well as for all other conventional engines were as follows:

1. Dismantling and Disassembly
2. Cleaning
3. Inspection
4. Repair and Replacement
5. Assembly of Sub-Assembly
6. Final Assembly
7. Block Test

According to this procedure the engine was broken down into its main components, each of which was completely disassembled. The individual parts were thoroughly cleaned, inspected, and repaired when necessary, or replaced with new parts. Reassembly could then begin, and routine replacements and the prescribed TO compliances were accomplished at the same time.

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28. Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to CG, AAF, 21 Aug. 1943, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.
29. H. P. Gulliver, General Plant Manager, Chevrolet Div. of General Motors Corp., to Chief, Maint. Div., ASC, 28 July 1943, in ibid.

Engines sent to the depots for overhaul, either from continental or overseas[30] installations, were stored in the reparable engine warehouse, from which they were taken to the overhaul stop. While in storage, the engine was usually protected from corrosion by a pliofilm envelope or a similar container. At some depots, the engine was bolted to an overhaul stand at the reparable warehouse and towed to the shop by a tug; other depots were provided with overhead conveyors for this purpose. Upon reaching the shop, the engine was placedin the disassembly line, although it was later found that an initial external cleaning of the entire engine was an important improvement, and this procedure was generally adopted.[31] After the engine was placed on the overhaul stand, it was precleaned with a steam and soap solution, and the external accumulations of grease and dirt removed. Having been cleaned at this station, the engines were inspected, and those found to be too badly damaged or mutilated to permit efficient handling in the disassembly line were sent to a special line where the serviceable and reparable parts could be salvaged.[32] Before precleaning was developed, the job of dismantling engines was sufficiently dirty and unpleasant to make the retention of labor for this unit very difficult at many of the depots.[33]

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30. Figures on engines sent to the continental depots by overseas theaters are cited in Chap. VI.
31. The first external precleaning machines were shipped to all depots during June 1945. Hq., ATSC, Daily Journal, 13 June 1945.
32. See report by Col. Albert Boyd, "Cleaning Processes," in "Report of ASC Maintenance Division Conference, Mobile ASC, 20-21 December 1943," in TSCHI-2 files.
33. See TWX, CG, MASC to CG, ASC, 14 Jan. 1944, in TSPCP 248, Wage Scale; 1st ind. (Brig. Gen. E. E. Adler, Chief, Management Control, ATSC, to CO, OASC, 12 Oct. 1944), Col. C. C. Minty, Dep. Comdr., OASC, to Dir., ATSC, 3 Nov. 1944, in TSCHI-2 files.

Various methods were tried to facilitate the operation of production-line disassembly. At Mobile, beginning in January 1945, a unit set up in the reparable engine warehouse removed magnetos, carburetors, and other accessories, and a preparation station was added at which still other parts were removed and the thrust nut broken. The engine was then run through a wash booth and sprayed with a hot soap solution to loosen external grease before being sent to disassembly. These innovations permitted some simplification of the disassembly line.[34]

The process of dismantling the R-1820 engine, or breaking it down into its main components, consisted of 53 separate steps, as outlined in the Technical Orders. That is, the spark plugs, oil and fuel lines, generator, cylinders, magnetos, supercharger, oil pump, fuel pump, carburetor, propeller shaft, and other parts were removed in a specified order. In addition, the nine cylinder assemblies were stripped of the valve springs, valves, tappets, and other parts; and the crankshaft, master rod, and articulated rods were likewise disassembled.[35] As already indicated, all these operations were originally performed at one station by a crew of skilled engine mechanics who worked on one engine until it was completely dismantled. As pressure for a much greater output of engines mounted, however, the process of disassembly, like the other stages of overhaul, was broken down into many simple jobs which relatively unskilled men and women could learn readily, and conveyor systems were installed in the shops at the same time. Moving floor conveyors were provided to carry the engines in an unbroken line past a series of

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34. "History of the Mobile ASC, January 1945 through March 1945," p. 181.
35. TO AN 02-35GC-3, 25 Nov. 1943, revised 15 April 1945, pp. 51-84.

stations at each of which nuts, bolts, and lock wires were removed, many of them by fast power wrenches, and the parts lifted off and placed on parts trucks. Overhead conveyors also began coming into use in the disassembly unit. Parts trucks were thereupon discarded, and disassembly was handled as follows: The engine parts, as they were removed, were placed in partitioned baskets, properly tagged to identify the engine to which they belonged, and these were hung on the overhead conveyor. The baskets were designed to hold complete assemblies, such as impeller and shaft assemblies, in such a way that the parts did not come into contact with each other. Parts too large for the baskets were tagged and hooked individually on the conveyor. Such a system was in partial operation at Fairfield early in 1944,[36] and at Mobile by August of the same year.[37]

The engine parts on the conveyor belt were routed directly to the cleaning unit. Essentially, the cleaning of engine parts consisted of three operations: the removal of heavy oil, grease, and sludge by a degreasing machine; the softening of carbon deposits by immersion in a special solution; and the removal of hard carbon by blasting, brushing, or scraping. Only cylinder heads, valves, and the insides of pistons could safely be blasted. Further, magnesium and other nonferrous parts were washed by special methods.[38] The depots were provided with a small

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36. "History of the Fairfield ASC, February 1943 to October 1944," p. 325. See Manual of Engine Parts Handling Baskets, published by the Air Service Comd., 25 May 1944, Exhibit C, "Maintenance Division Annual Report, 1944," in TSCHI-2 files.
37. "History of the Mobile ASC, January 1945 through March 1945," p. 180.
38. TO AN 02-35GC-3, 25 Nov. 1943, revised 15 April 1945, p. 85.

amount of degreasing, carbon solvent, and blasting equipment before the war, but a considerable amount of hand brushing was nevertheless necessary. One of the important ways in which engine production was later increased was by the development of more effective mechanical cleaners, the conveyorizing of the depot cleaning units,[39] and the consequent reduction of the hand labor involved.

The cleaning process, developed particularly at the Middletown Air Depot in 1943 and adopted throughout ATSC, represented a considerable elaboration of the three steps mentioned above. Like the disassembly unit, parts cleaning was put on a scheduled basis, each employee having a highly specialized operation to perform. The parts baskets coming from the disassembly line on the overhead conveyor were first carried through an industrial washer for initial degunking. Second, they were immersed for 15 minutes in a degreasing tank containing an agent known as Oakite No. 37 heated to the boiling point. The third step was a two-hour soak in a carbon softening bath usually of Turco-Fuzee, the fumes from which were harmful to employees if effective ventilation were not provided. Fourth, the parts were rinsed in an industrial washer containing Oakite; and fifth, the baskets were routed to cleaning booths set up for each of the subassemblies. Here, the parts were hand-sprayed, and bearing surfaces and rusted parts were buffed and polished. Also, the carbon deposits remaining on pistons and valves were removed by blasting with processed

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39. By June 1945, plans were completed for installing a standard conveyorized cleaning plant at all depots except Miami. It was estimated that these installations would speed up engine production by eliminating 80 to 90 per cent of the hand cleaning formerly required. Hq., ATSC, Weekly Activity Report (WAR), 9 June 1945.

wheat, clover seed, or plastic pellets.[40] All bearings were placed in a special basket during disassembly and were sent to the Bearings Sub-Unit for cleaning and repair. Here they were soaked in a carbon solvent, hand-sprayed with dry cleaner, buffed, inspected, and packed in moisture-proof paper until ready for re-installation.[41]

The inspection of engine parts after they had been cleaned was a stage of the overhaul process less amenable to production-line methods than the other stages. In addition to a visual check of all parts for obvious defects, two methods of inspection were used--magnetic inspection, and checking limits and tolerances by gages. Magnetic inspection, the use of which was greatly extended during the war, could be employed on all ferrous parts except bearings,[42] and it was extremely useful for detecting flaws, such as nonmetallic inclusions and cracks. The part to be inspected by this method was first placed in the magnetic field set up by a magnetizing machine in such a way that the lines of force ran in the desired directions. Particles of iron oxide were then applied to the part while it was being magnetized by sluicing it with a suspension (continuous flow method). Occasionally, however, the part was dipped in the iron oxide suspension after it had been magnetized (residual method). To the skilled inspector, particular patterns formed by the iron oxide particles were indicative of a leakage field and thus of the presence of a flaw in the metal, either surface or subsurface. Depending on the

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40. Early in 1944, a commercially produced air blast cleaner, "Lingo," was found in tests to be superior to any other material thus far used. WAR, 25 Feb. 1944.
41. See report by Col. Albert Boyd, "Cleaning Processes," in "Report of ASC Maintenance Division Conference, Mobile ASC, 20-21 December 1943," in TSCHI-2 files.
42. The particles of iron were found very difficult to clean off the bearings once they were magnetized.

extent of the flaw, the part was either junked or accepted as still serviceable. After being magnafluxed, the parts were demagnetized and rinsed to remove the iron oxide. Cylinder barrels, master rods, articulated rods, crankcases, crankshafts, and reduction gears were among the parts most carefully inspected by this method.

A great number of parts were further checked very accurately for proper dimensions by micrometer gages of various sorts. The horizontal alignment of the master rod, for example, was checked by a surface gage, and an inside dimension gage was used to test cylinders for out of round and taper. In addition, cylinders were air-tested for leaks. Such parts as intake and exhaust valves were examined both visually for pitting and by gages for proper height; and special tools were used to test valve spring tension and piston pin alignment.[43]

Parts not accepted as serviceable by the inspectors were either replaced with new parts from the parts pool or repaired. Minor repairs consisted of removing scratches, nicks, and burrs by the use of crocus cloth or light stoning. Damaged threads or gear teeth could be dressed to a limited extent, but the repair of any part except air deflectors by welding was forbidden. Such operations as refacing valves, grinding and lapping valve seats, and fitting piston rings might be considered secondary repair. A more advanced sort of repair was the electroplating of worn parts to build them up to required tolerances. Copper, cadmium, indium, chromium, lead, and silver plating was accomplished, but lead plating of master rod bearings was perhaps the most common process. Also, cylinders

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43. TO AN 02-35GC-3, 25 Nov. 1943, revised 15 April 1945, pp. 90-122.

were honed in special machines, and some of them were chrome plated. Certain serviceable parts ready for final assembly were enameled, in particular the crankcase front section, supercharger section, and the cylinders.[44]

The inspection, repair, and reassembly of certain parts and accessories--carburetors, magnetos, generators, oil and fuel pumps, superchargers, ignition harnesses, starters, instruments, spark plugs, and the like--were accomplished in special units. Some of these units were in existence long before the war, but because of critical shortages during the war they came to be of great importance and efforts were made to put them all on a progressive overhaul basis. At Mobile, the starter and generator units were the first to be so organized. For this process, assistance was received from Ford Motor Company engineers. The various steps in the overhaul of these items were broken down into simple jobs, and conveyors were ultimately installed. On 30 January 1943, after the new system had been in operation for one month, the Mobile Air Depot was turning out three times as many starters and generators as formerly, with only two-thirds as many workers. Mobile published a pamphlet on each of these two production lines, and both were later issued by the Air Service Command.[45] A considerable increase in efficiency was also effected at the other depots by the installation of production lines for accessory overhaul. At Fairfield, for example, the number of man-hours required for magneto overhaul was thus reduced from 4 to 2 hours, for generators

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44. Ibid., pp. 123-64.
45. "History of the Mobile ASC, February 1943 to July 1944," p. 127.

from 6 to 3.5 hours, for ignition harnesses from 8 to 4 hours, and for spark plugs from 17 minutes to 3 minutes.[46] The progressive overhaul system permitted the use of unskilled labor and considerably improved both the quantity and quality of the output, but its continued efficiency depended upon a steady flow of reparables and replacement parts.[47]

The assembly of subassemblies involved such operations as the following: the propeller shaft, reduction gears, cam, and cam drive were fitted into the crankcase front section; the impeller and other parts were installed in the supercharger housing; and the master rod and articulated rods were assembled. In performing this work, certain parts, such as gaskets, packing, piston pin retainers, and oil seals, were always to be taken from new stock. Great care had to be exercised to prevent dirt and foreign matter from falling into the engine. Corrosion preventive was to be applied to pistons and other parts, and torque indicating wrenches were prescribed for drawing up nuts to proper torque values.[48]

After being built up, the subassemblies were composed of the same parts that made up the original engine except for the occasional replacements. The tagging of parts and parts baskets has already been mentioned, and it was by this system that the parts belonging to a particular engine were brought together. During 1942, however, the practice of "scrambling" or pooling engine parts was adopted at the Mobile depot. That is, in the

46. "History of the Fairfield ASC, February 1943 to July 1944," p. 127.
47. See report by Col. R. J. O'Keefe, "Progressive Overhaul of Accessories," in "Report of ASC Maintenance Division Conference, Mobile ASC, 20-21 December 1943," in TSCHI-2 files.
48. TO AN 02-35GC-3, 25 Nov. 1943, revised 15 April 1945, pp. 165-204.

building up of subassemblies and in final assembly, no attempt was made to match the parts which originally went together to make up an engine. It was possible therefore to omit tagging, and certain production-line problems were solved at the same time. On the other hand, an excessive test block rejection rate of 24 per cent in January 1943 was ascribed to scrambling, and, on the recommendation of representatives of the Air Service Command who studied the problem in March 1943, the policy was changed. Thereafter, interchanging parts inside the crankcase was forbidden.[49] And in 1945 the depots were instructed to discontinue all parts scrambling, so that even the interchanging of parts outside the crankcase came to be prohibited.[50]

Final assembly consisted principally of the following steps. The supercharger front housing was mounted on the engine stand and the crankcase rear main section was bolted to it. The crankshaft, master rod, and articulated rod assembly was then lowered into place, and the crankcase main front section and front section proper were fitted together. Gaskets and oil seals were inserted at the proper places as the crankcase was assembled. Next, the pistons were fastened to the piston rods and the cylinders installed, together with the push rods and rocker arms. Finally, the supercharger rear housing, intake pipes, magnetos, spark plugs, carburetor, and the other parts were installed, and required adjustments were made. Certain of the final assembly operations were to be overseen by the shop foreman or inspector and an indication to that effect made on the inspection form.[51] Final assembly lent itself particularly well

49. "History of the Mobile ASC, January 1939 to February 1943," pp. 67-68.
50. Hq., ATSC, Daily Journal, 27 April 1945.
51. TO AN 02-35GC-3, 25 Nov. 1943, revised 15 April 1945, pp. 205-21.

to production methods because the parts had all been processed and, unlike disassembly, there were almost no unpredictable conditions to be confronted. For example, in the big Farm Show Building overhaul shop operated by the Middletown Air Depot, final assembly was considered to be the only section in the shop thoroughly organized on a progressive line basis.[52]

When final assembly and the last shop inspection were completed, the engine was transported to a cell in the test block.[53] Here it was mounted, equipped with a four-bladed test club, and connected to the oil and fuel lines and the various controls and instruments. The test propeller was pulled through at least four revolutions before the engine was started. The three-hour run-in recommended for the R-1820-97 and associated models was broken down into a specified number of minutes at several different r.p.m. and manifold pressures. The last 30 minutes were to be run at 100 per cent power and manifold pressure. Fuel and oil consumption, oil flow, cylinder head temperatures, carburetor air temperature, and power output were to be observed and the readings recorded at frequent intervals on the test log. Further, the idling and acceleration characteristics were noted. From these data, the corrected horsepower of the engine could be computed. If the engine being tested turned up approximately the desired horsepower without developing any failures or any symptoms of malfunctioning, it was accepted. Otherwise, it was rejected and returned to a special shop for further work.[54] The rejection rate at

52. Interview with Maj. J. U. Biern, Officer in Charge, Harrisburg Shops, Maint. Div., MATSC, 16 Jan. 1945.
53. The design of the test block improved considerably during the war. See "History of the Acquisition of Facilities for the Air Service Command," p. 89.
54. TO AN 02-35GC-3. 25 Nov. 1943, revised 15 April 1945, pp. 222-30.

the test block varied somewhat, but the national average during 1944 approached 2 per cent. In October 1944, the 5,000th engine was processed through the test block at Fairfield without a rejection for excessive oil consumption, a frequent cause of difficulty.[55] After a successful test run, the engine was drained, cleaned, treated against corrosion, and placed in a pliofilm envelope for storage.

Even though not all departments of the depot engine shop could be described above, it is apparent that it was a large and complex industrial activity. At depots whose output averaged 40 engines per day, as at Middletown, as many as 200 engines were often in various stages of cleaning, disassembly, rework, final assembly, and testing at one time.[56]

Special Maintenance Developments

Maintenance of Wood-Construction Airplanes. Although combat aircraft were almost universally of all-metal construction like the B-17,[57] the Army Air Forces maintained several thousand wood-construction trainers throughout the war. During the first half of 1943, six fatal accidents involving wood-constructed PT-19's were reported. Of these, three or four were thought to have resulted from poor maintenance work by commercial overhaul installations and the subdepots. Further, the poor maintenance was ascribed to the shortage of skilled woodworkers, and plans were made

55. "History of the Fairfield ASC, February 1943 to October 1944," p. 326.
56. Figures on depot engine production are given in Chap. VI.
57. The British Mosquito, F-8-DH, was of wood construction.

to prepare an instructional manual to remedy the deficiency.[58] Late in 1943, the Air Service Command examined the situation and recommended that further procurement of these models be discontinued. The airplanes built wholly of wood or with wood wings were the PT-19, PT-23, PT-26, AT-10, and C-76. Others were built with wood spars and plywood leading edges, like the AT-17; and a number of airplanes originally of all-metal construction, particularly AT-6's, had been fitted with substitute surfaces and monocoques of wood because of the critical shortage of aluminum.[59] The Air Service Command recommendation was acted on favorably. Later, even the use of wood for such purposes as floor boards, hatches, and seat assemblies was adversely criticised.[60] Thus, the movement away from wood construction which started as early as 1924 was still continuing.[61]

Specialization and Localization. In the discussion of depot reconditioning of airplanes and engines, the assumption was allowed to stand that each depot was provided with a full complement of specialized repair units and was therefore prepared to accomplish the complete overhaul of all models of airplanes and engines and their accessories. In actuality, the Air Service Command, in the interests of efficiency, stipulated what models of airplanes and engines were to be overhauled at each depot. For example, the DIR of B-17's was localized at Fairfield, Oklahoma City,

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58. R&R, Comment No. 1 and later comments, Lt. Col. Jack E. Shuck, Chief, Aircraft Sec., Maint. Div., ASC, to Col. W. T. Hefley, Chief, Control Sec., Maint. Div., ASC, 30 June 1943, in TSPCP 461, Civilian Training Material.
59. Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to CG, AAF, 10 Nov. 1943, in TSAGD 452.1, Airplanes, General.
60. Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to CG, Mat. Comd., 10 Feb. 1944, in ibid.
61. See "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," p. 37.

and Warner Robins; B-24's were sent to Middletown, Ogden, and Spokane; and B-25's to San Antonio and San Bernardino.[62] Only by concentrating the reparable airplanes in such a manner could production lines continue to function properly. The specialization program, so far as airplanes and engines were concerned, was set forth in a series of Technical Orders beginning in October 1944.[63] The airplanes and engines in which each depot was to specialize as of 1 January 1945 are indicated on the chart (see Figure 7).

Specialization in the overhaul of accessories also came to be regarded as of importance.[64] In April 1944, the repair of aluminum propeller blades was localized at Fairfield, Warner Robins, San Antonio, and Sacramento, and each of the other areas was instructed to which of these depots it was to send its reparable propellers. The same directive also designated other depots as the sole overhaul agencies for steel propellers, starters, generators, armatures, turbosuperchargers, glider pick-up systems, tires, tubes, automatic pilots and other gyro instruments, photographic equipment, and bombsights.[65] Thereafter, a number of changes and adjustments were made in the accessory overhaul program.[66] During 1944, the overhaul of the various accessories was assigned to the depots

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62. Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to CG, FASC, 12 June 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.
63. TO 00-25-2, 20 Oct. 1944; TO 00-25-2, 16 April 1945; and TO 00-25-2, 15 Aug. 1945.
64. Col. Albert V. Endress, Acting Chief, Control Sec., Maint. Div., ATSC, to CG, OATSC, 23 Nov. 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.
65. TO 00-25-11, 20 April 1944.
66. TO 00-25-11, 1 June 1944; TO 00-25-11, 14 Aug. 1944; TO 00-25-11, 10 Nov. 1944; and TO 00-25-11, 12 Jan. 1945.

as indicated on the chart (see Figure 7). It may be seen that each depot ran overhaul units, many of them on a progressive overhaul basis, for 15 to 20 different accessories and one to four different models of airplanes and engines.

Storage of Aircraft. Another responsibility of considerable importance assumed by the maintenance divisions of the air depots during 1944 was the storage processing of aircraft declared excess to AAF needs. As more and more training-weary and war-weary airplanes accumulated at air bases in the United States it became apparent that an orderly system of storage and also of disposal would have to be arranged. A discussion of the disposal system, which involved transferring the title for excess airplanes to the Reconstruction Finance Corporation, is not relevant here,[67] but the storage system should be briefly described. Flying organizations with aircraft in excess of their needs were to notify the Aircraft Distribution Office, AC/AS, MM&D of this fact. If the Aircraft Distribution Office could not arrange an immediate reassignment to a station where they would be of use, the airplanes were ordered into storage. Four classes of storage aircraft were distinguished:

1. Aircraft being held as an optional or strategic reserve.

2. Aircraft being held for assignment, reassignment, rework, processing, or shipping.

3. Aircraft being held pending decision as to their declaration as excess or surplus.

4. Aircraft having been declared excess and awaiting disposition.

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67. This subject is reserved for a special monograph on salvage and disposal.

The aircraft in the first three classes were to be maintained in operational condition, and those in Class 4 in inactive storage.[68] The Air Technical Service Command issued instructions for processing aircraft in and out of storage,[69] which work was generally performed by maintenance personnel at the air depots. The processing of airplanes for Class 4 storage was more thorough than for the first three classes, involving as it did some disassembly and elaborate precautions against corrosion.[70]

An example of the kind of airplane held in storage is supplied by the life history of a B-17 which was stored at the Fairfield Air Technical Service Command for some months. This particular airplane, a B-17F, serial number 42-5346, was delivered by the contractor 17 November 1942, at a cost of $316,426. After a short period in the Modification Center at Cheyenne, it was sent to West Palm Beach, and thence overseas as part of Project No. MK-70. Upon arrival in North Africa, it was assigned to the 816th Bombardment Squadron of the Twelfth Air Force at "Blot" (Casablanca). The airplane saw combat both there and at "Duke" (Italy) where it was transferred after the invasion of Italy. On 2 July 1943, it was condemned for further use, because certain battle damage apparently could not be repaired, but means of repair must shortly thereafter have been found, because it was ferried back to this country later in July and assigned to the Air Transport Command at Homestead. During the next year

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68. AAF Reg. 65-86, 14 June 1944.
69. TO 01-1-7, 14 July 1945.
70. Despite such precautions, it was found that the climate in some parts of the United States caused very rapid deterioration of stored airplanes. This was especially true of aircraft stored at Mobile. "History of the Mobile ASC, January 1945 through March 1945," p. 118.

and a half, it was flown rather infrequently, although still kept in flyable condition. In May 1944, the crew chief was Staff Sergeant A. T. Dobrias, with Sergeants Pfiefer and Dunn as assistants, according to the airplane's Form No. 41B. At last, it was declared excess and sent to Fairfield where it was processed into Class 4 storage on 11 January 1945. Early in July 1945, the Flight Test Section of the Fairfield depot was ordered to process this airplane out of storage and prepare it for "fly-away" to a Reconstruction Finance Corporation field for final disposal.[71]

The airplane was given a shake-down inspection to insure its flying safety for at least one flight, and the armament and certain radio equipment were removed. The shake-down revealed many patched bullet and flak holes in the wing, and a large hole in the left spar. The spar at this point had been reinforced by a sort of clamp. The airplane before the test flight had accumulated only 998 hours and 35 minutes of flying time, after two years of service, and the flying time on the engines ran from 500 to over 800 hours.[72]

Miscellaneous Activities of Depot Maintenance Personnel. Modification, or the alteration of airplanes in order to adapt them better to particular purposes, was another important depot activity. Although considerable modification was performed by depot maintenance personnel, such work was clearly not of a piece with the reconditioning of aircraft and engines, and it was, in fact, primarily the responsibility of special

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71. These facts were collected from the inadequate historical record of the airplane on file in the Aircraft Statistics Section, ATSC, and from the maintenance inspection forms belonging to the airplane.
72. Form 41B; also interview with V. O. Knox, General Foreman, Flight Test Sec., FATSC, 10 July 1945; and personal examination of the airplane.

modification centers. The facilities of the air depots were used merely to supplement the work of these installations.[73]

Many maintenance developments of the period 1939-1945 have been omitted from the foregoing discussion. Among these are several important activities of the Air Technical Service Command and the air depots: airplane parts preservation and anticorrosion work;[74] the publication of such maintenance periodicals as Plane Facts;[75] the Gadget Digest,[76] and the Airborne Communications Maintenance Digest;[77] the vehicular maintenance program, in connection with which a production-line maintenance system was organized;[78] the reclamation of bearings;[79] and a number of B-29, radar, and jet engine projects.[80] Further, a large number of less spectacular, routine operations at the various maintenance installations have necessarily been omitted: the large manufacturing projects at both the air depots and subdepots, parachute inspection and packing, the repair of flying clothing, the instruments devised for the overhaul of such accessories as turbosuperchargers, and the maintenance of shop facilities.

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73. See draft AAF Historical Study, "The Modification of Army Aircraft in the United States, 1939-1945."
74. See TO 01-1-166, 15 March 1944, Preparation of Aircraft for Overseas Shipment.
75. Plane Facts was published monthly by Headquarters, ATSC as a simple, terse, yet readable collection of hints for AAF maintenance and supply personnel. The "Victory Issue," Vol. III, No. 9 (September 1945) presented an interesting chronology of maintenance and supply developments beginning 7 December 1941. The periodical was discontinued with the September 1945 issue.
76. Issued as TO 00-55-2 for the purpose of informing personnel in the field how to make or use various time- and labor-saving devices, many of them the inventions of AAF mechanics, civilian and military. New pages were prepared from time to time.
77. A confidential pamphlet published occasionally by the Maintenance Division, ATSC. It dealt entirely with maintenance procedure for AAF communications equipment.
78. See TO 19-1-133, 15 Dec. 1944, and TO 00-30-24, 15 Dec. 1944.
79. "Maintenance Division Annual Report, 1944," p. 20.
80. Ibid., pp. 18-21.

Finally, other sources must be consulted for an account of special operating conditions at particular depots and other installations.[81]

81. Descriptions of the detailed operations at the various depots are to be found in the histories of the area air service commands in AFSHO files.

Chapter VI

MAINTENANCE STATISTICS

To compile statistics that reflect adequately the magnitude and diversity of AAF maintenance operations during the period 1939-1945 is a difficult problem. Maintenance inspection was a continuing process, as was the performance of the first three echelons of repair by the flying organizations and the subdepots. Despite the several official forms to be accomplished by maintenance personnel, not all these numerous operations could be made matters of record. Fourth echelon maintenance at the air depots, however, lent itself much better to statistical reporting, and to a large extent the figures cited here are taken from depot records.

The most general index to the total amount of maintenance work to be performed was the current inventory of airplanes and engines. That is, every AAF airplane, whether operational or inactive, required some degree of service until it was finally surveyed or declared excess and transferred to the Reconstruction Finance Corporation for disposal. As of 30 June 1944, there were 52,918 airplanes to be maintained within the continental limits; a year later there were 38,328 (see Figure 1). Included in the domestic airplane inventory of 30 June 1945 were approximately 3,800 airplanes which had already been returned from overseas theaters.[1]

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1. Interview with Capt. H. K. Crowl, Dispatcher, "White Project," Aircraft Distribution Office, AC/AS, M&S, at Hq., ATSC, 20 Sep. 1945.

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A considerable number of engines—an accumulated total of 74,214 by 30 June 1945—were also returned to the United States during the war when they were ready for overhaul.[2] Because of occasional complaints from overseas commanders about the quality of overhauled engines,[3] a policy adopted in 1944 stipulated that all new engines were to be shipped overseas and that combat aircraft operating in the United States were to be equipped with overhauled engines only. If overseas shipments of overhauled engines were later found to be necessary, priority was to be given engines which had just received their initial overhaul.[4]

The volume of reparable equipment reaching the air depots for fourth echelon work grew enormously during the war years.[5] The following table gives the number of airplane DIR's performed by each of the depots for the period from January 1940 through October 1943:[6]

Airplane DIR's[7]

DATE	FAD	MAD	MOAD	OAD	OCAD	RAD	SAD	SAAD	SPAD	WRAD	TOTALS
1940	64	46					35	63			208
1941	75	61					89	30			255
1942	51	188	13	12		2	11	21	4	2	304
to 1 Nov 1943	20	56	3	111	68	14	5	222	13	39	551

2. Interview with Capt. R. E. Baldauf, Maint. Control Sec., Maint. Div., Hq., ATSC, 20 Sep. 1945.
3. Maj. Gen. Clements McMullen, Chief, Maint. Div., ASC, to CG, AAF Serv. Comd, Mediterranean Theater of Operations, 30 June 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.
4. "Maintenance Division Annual Report, 1944," pp. 4-5.
5. For airplane and engine overhaul figures from 1931 through 1939, see "The Maintenance of Army Aircraft in the United States, Part I: 1921-1939," Figures 8 and 9.
6. Airplane DIR's were recorded as separate items only for the period through October 1943. Thereafter, the Maintenance Activity Reports lumped DIR's with other kinds of repair work.
7. Special Report, Airplane and Engine Overhaul, 1940-1941, in TSCHI-2 files; and Depot Maintenance Activity Reports, Jan. through Oct. 1943.

The total number of airplanes sent to the depots for all kinds of work, including minor repairs and modifications, greatly exceeded the DIR figures given above. Thus, in 1942, a total of 9,348 airplanes passed through the 11 depots then operating for modification and for repair work other than DIR.[8]

From the available statistics, the figures that best represent depot aircraft production from 1943 through 30 June 1945 are the total numbers of airplanes that underwent repairs, including DIR's, installations, and modifications, at the depot.

Airplane Repair at the Depots[9]

DATE	FAD	MIAD	MAD	MOAD	OAD	OCAD	RAD	SAD	SAAD	SBAD	SFAD	WRAD	TOTALS
1943	1718		1002	2028	371	2796	774	2356	2891	448	207	777	15368
1944	1220	81	1018	1671	302	2121	965	4524	1203	1722	551	1451	16829
to 1 Jul 1945	153	71	148	338	99	368	128	1535	392	686	142	204	4264

It may be seen that the total for 1944 is substantially higher than for 1943, whereas the total for the first half of 1945 is scarcely more than one-fourth of that for the preceding year, indicating that activity for that period had fallen off 50 per cent. It is estimated that, out of a total of 16,829 airplanes passing through the 12 depots in 1944, approximately 30 per cent underwent modifications, 17 per cent received DIR's, and the remaining 53 per cent, miscellaneous repairs.[10] The proportion

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8. Report, Total Airplane Overhaul and Repair, prepared by the Maint. Control Sec., Hq., ATSC, in TSCHI-2 files.
9. Depot Maintenance Activity Reports, Jan. 1943 through June 1945.
10. "Maintenance Division Annual Report, 1944," App. 9.

of DIR's to modifications and minor repair over the period from January 1942 through November 1944 is represented in the accompanying graph (see Figure 8).

Over 90 per cent of the engines sent to the depots were overhauled; the remainder underwent minor repairs and modifications. The following table reveals the enormous increase in the number of engines passing through the depots from 1940 through 30 June 1945.

Engine Overhaul and Repairs[11]

DATE	FAD	MIAD	MAD	MOAD	OAD	OCAD	RAD	SAD	SAAD	SBAD	SPAD	WRAD	TOTALS
1940	836		655					757	1350				3598
1941	1741		1238					1573	2767				7319
1942	4359		5226	1528	767		105	5291	7927			135	25338
1943	6356		6209	5076	4845	8257	2645	6321	15413	1615	1048	7127	64912
1944	12854	1312	9473	8879	5579	13210	6309	10054	17239	7297	5736	9635	107577
to 1 Jul 1945	7654	2855	6245	4576	3165	6015	3962	4648	9599	2628	4758	3760	59865

From 1940 through 1944, the annual totals for all depots increased from 3,598 to 107,577, or nearly 30-fold. In a single depot, Fairfield, the increase over the same period was 15-fold. The accumulated totals of engines overhauled and repaired in the depots from 1942 through November 1944 are shown in the graph (see Figure 9).

The other repair and overhaul activities at the depots were also of great importance although not fully discussed in the foregoing chapters.

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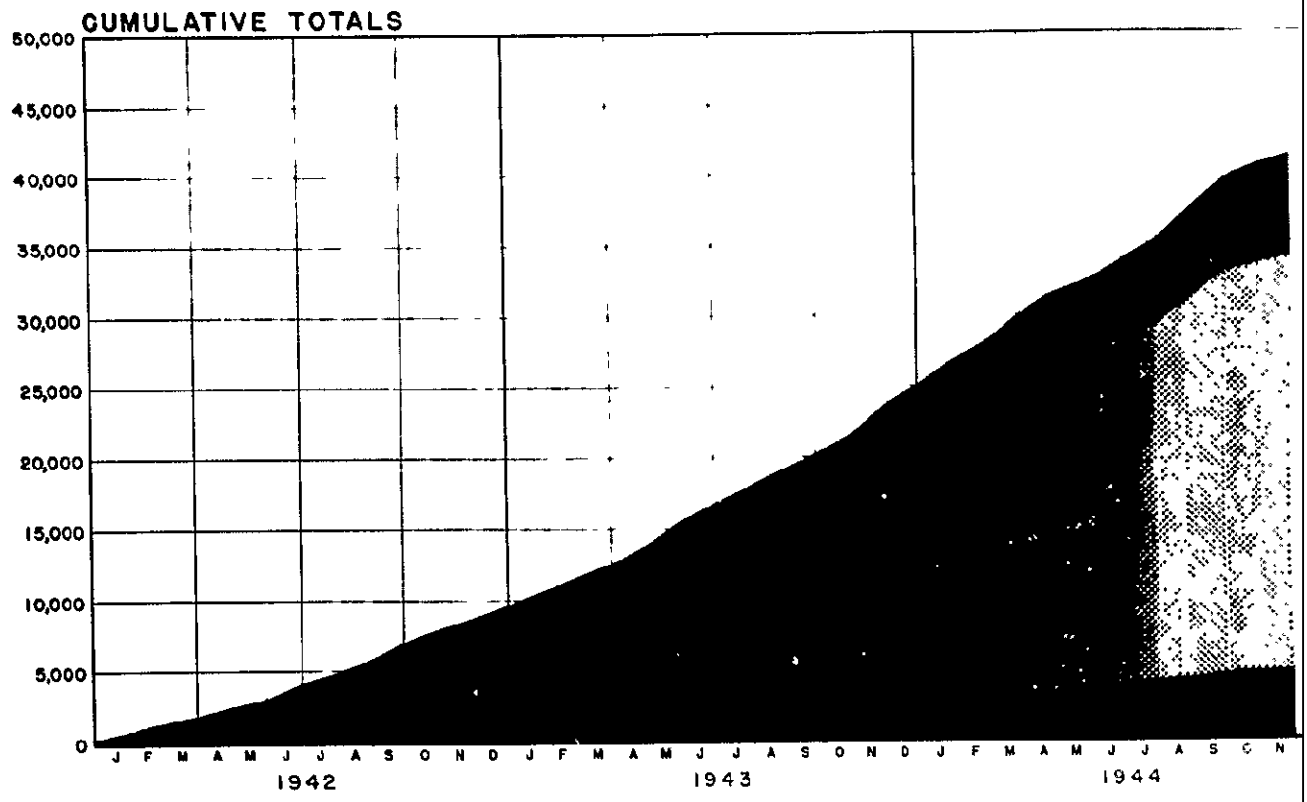
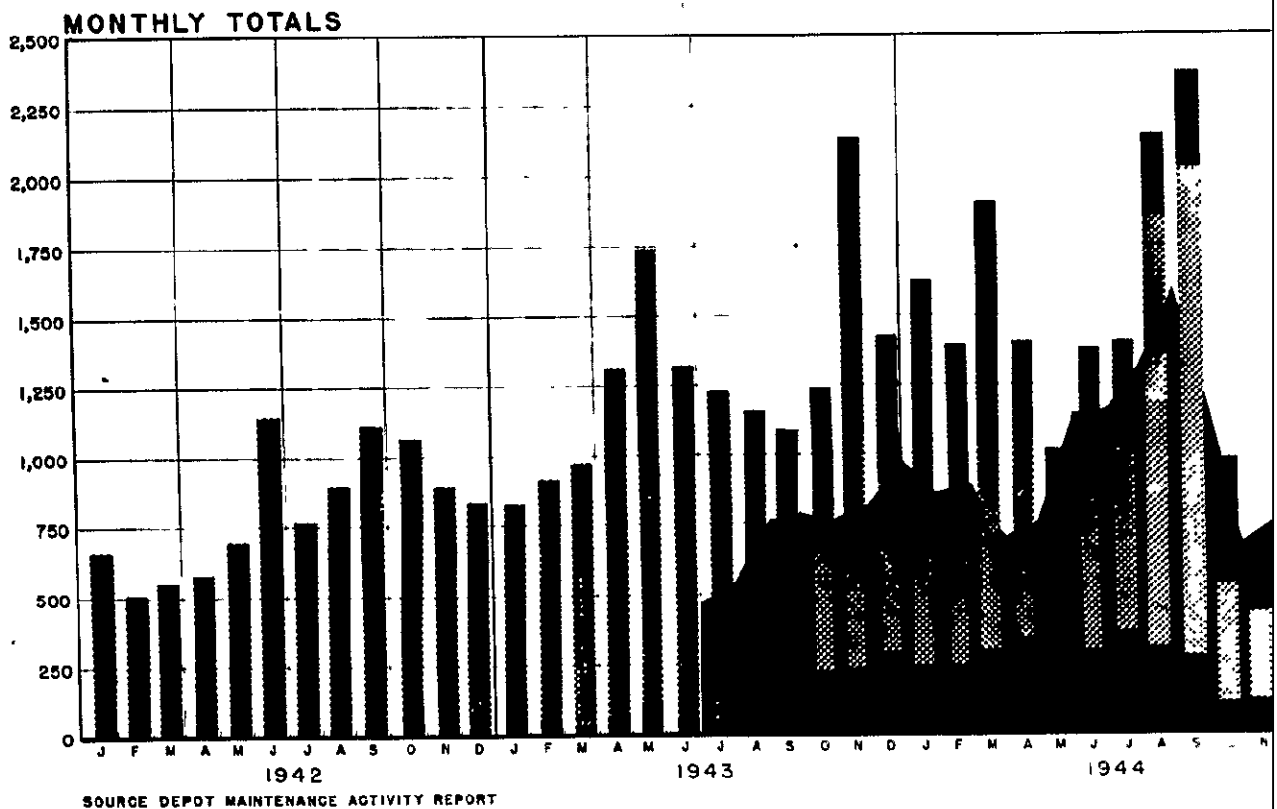
11. Special Report, Airplane and Engine Overhaul, 1940-1941, in TSCHI-2 files; Summary, Engine Major and Minor Repair, 1942, in ibid.; Depot Maintenance Activity Reports, Jan. 1943 through June 1945.

TOTAL AIRCRAFT RETURNED TO SERVICE

FOURTH ECHELON





SOURCE DEPOT MAINTENANCE ACTIVITY REPORT

SEE BINDER 16

MODIFICATION
REPAIR
OVERHAUL
TOTAL OUTPUT

TOTAL WORK BACKLOG

FIGURE 8

TOTAL AIRCRAFT ENGINES RETURNED TO SERVICE
FOURTH ECHELON

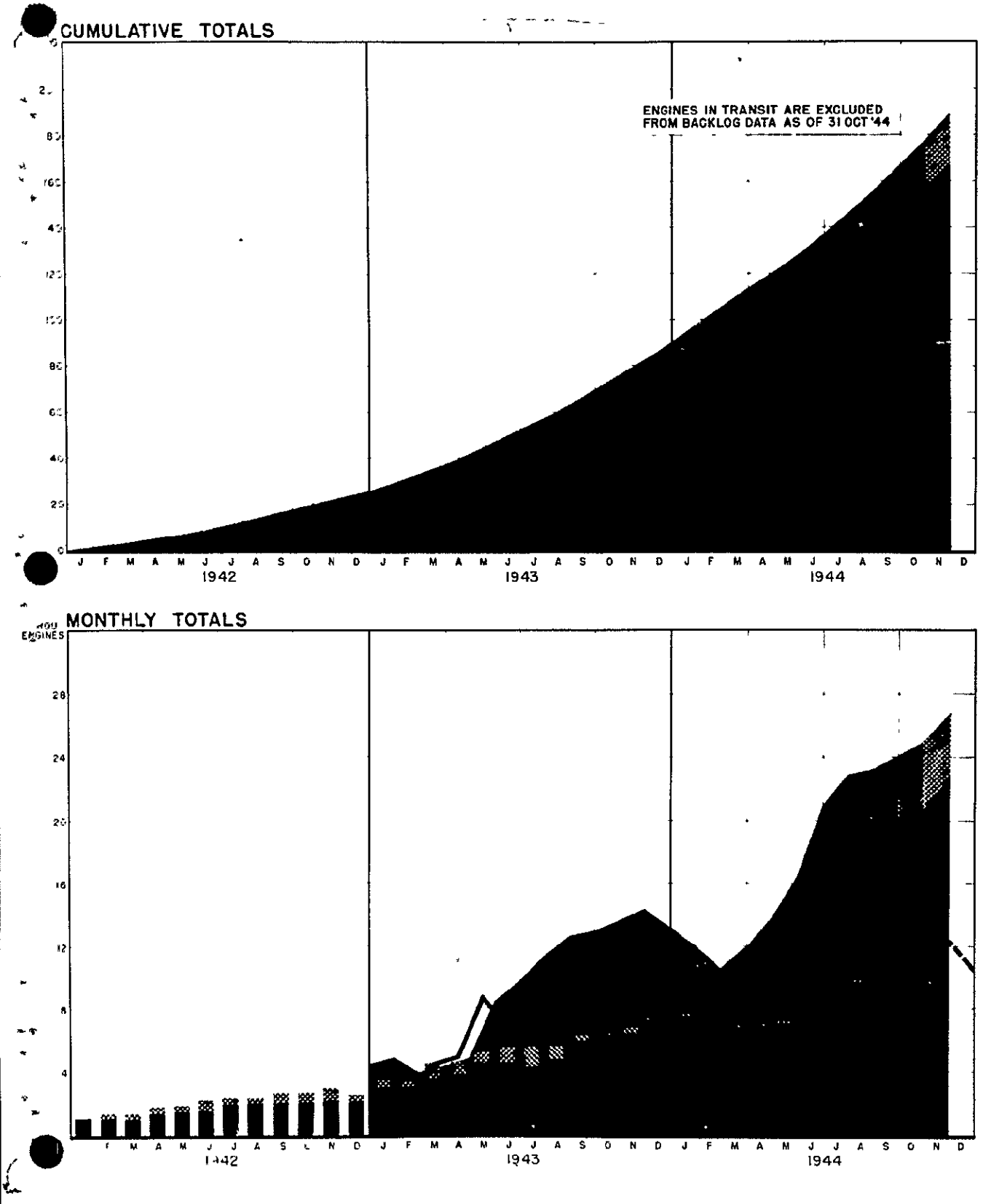


FIGURE 9

The quantity of units produced during 1944 by some of the accessory repair departments is shown in the table (see Figure 10). The depots in which the various repair activities represented in the graph were located in 1944 may be determined by consulting the chart showing ATSC overhaul specialization (see Figure 7). It may be seen, for example, that starter overhaul units were in operation at Middletown, Mobile, San Antonio, San Bernardino, and Spokane. The storage of airplanes was another depot activity which came to be of importance during 1944. In that year alone, 5,236 airplanes were prepared for storage. Of these, 2,070 were processed for flyaway, leaving 3,166 still in storage.[12] It was anticipated that by 31 March 1946 a total of 68,500 aircraft would have been declared excess to AAF needs in the United States.[13]

To the great volume of work accomplished at the depots must be added the fourth echelon work allotted to the contract overhaul agencies and the airlines shops. Virtually all the overhaul and reconditioning of primary training equipment was done on contract. Up to the end of June 1944, it was estimated that these activities had reconditioned approximately 6,000 airplanes, overhauled 25,000 engines, and repaired a proportionate number of accessories, instruments, and propellers.[14] The fourth echelon work performed in the airlines shops for Air Transport Command equipment

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12. "Maintenance Division Annual Report, 1944," App. 12.
13. Daily Diary, AC/AS-4, 20 Sep. 1945, in AFSHO files.
14. R&R, Lt. Col. Henry W. Dickerson, Administrative Asst., Maint. Opns. Sec., ASC (ASCMMlA) to Col. Albert Boyd, Dep. Chief, Maint. Div. (ASCMD1), 22 June 1944, in files, Contract Serv. Br., Maint. Control Sec., ASC. No routine reports on the amount of equipment repaired were required of the contract agencies, inasmuch as the contracts themselves constituted a rough statistical record. Also, interview with J. F. Brown, 19 Sep. 1945.

MAINTENANCE OF REPRESENTATIVE ACCESSORIES AND MISCELLANEOUS ITEMS TOTAL ALL U.S. AIR DEPOTS -

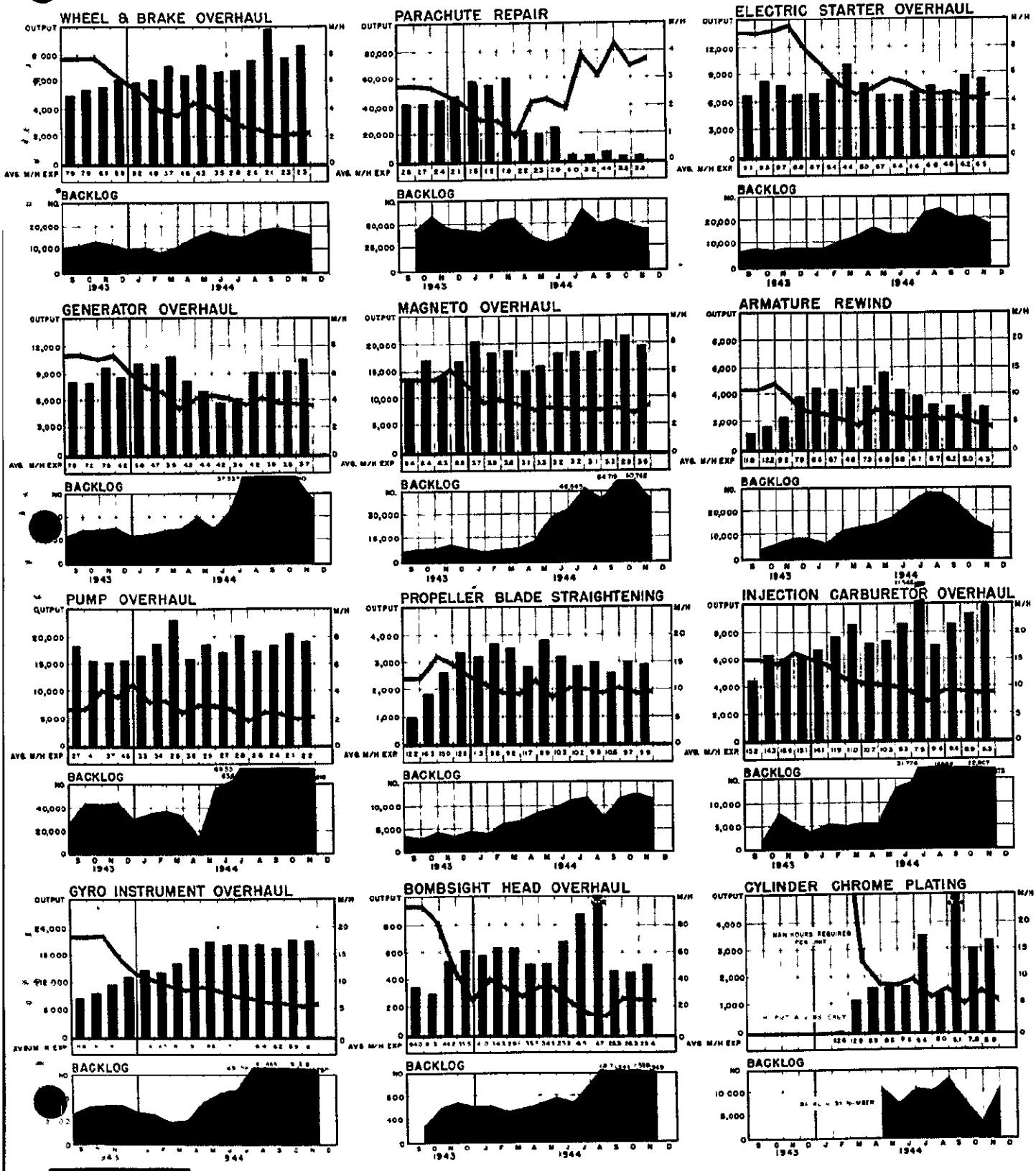

FIGURE 10

during nearly three years of operations could be estimated at 600 airplanes reconditioned and 4,000 engines overhauled.[15]

The number of maintenance personnel required to carry the work loads at the depots became very large, as is indicated in the following table.

Depot Maintenance Personnel[16]

DATE	FAD	MIAD	MAD	MOAD	OAD	OCAD	RAD	SAD	SAAD	SBAD	SPAD	WRAD	TOTALS
1941	1545		1408					905	1736				5594
1942	10358		9647	5599	5612	298	317	5851	13213	157	212	1189	52453
1943	8046	5	9156	8449	5894	7714	4668	8480	10640	5466	4455	6771	79744
1944	6114	1561	6144	5757	4404	7386	3307	6927	7599	4466	3120	4952	61737
1945	6049	1996	5932	5747	4021	7841	3198	6872	8531	4367	3476	4995	63025

From 25 to 29 per cent of the maintenance personnel at each of the depots was "indirect labor" which performed inspection, clerical, and supervisory work. In addition, from 25 to 140 officers were assigned to the Maintenance Division at each depot in technical and supervisory capacities. A very large part of the maintenance employees at both the depots and the subdepots received their training as mechanics in the extensive training programs which had to be developed to supply wartime needs. In all, no fewer than 96,000 unskilled workers received training up to the end of

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15. Ibid.
16. All strength figures, except those for 1941, are given as of 30 June. (Depot Cost Report, 1941; Monthly Report of the Distribution of Civilian Personnel, 30 June 1942; Depot Maintenance Activity Reports, June 1943, 1944, and 1945.) In the table, the totals of maintenance personnel in 1942 and 1943 are made up in part of trainees. After July 1943, all trainees were carried on personnel and training rosters and were therefore not included in the maintenance personnel totals. ATSC historical monograph, "History of the Procurement, Training, & Retention of Civilian Personnel, Part III, 1943-1944," p. 137.

1944, and at their peak these programs included over 13,000 maintenance trainees.[17] But even this great supply of trained workers was insufficient to man to maximum capacity all the maintenance installations at the 12 depots. At some depots, such as San Antonio, the ratio of workers per 100 square feet of shop area was much higher than at Miami or Spokane (see Figure 11). The chief reason for this uneven utilization of depot facilities was that in some areas sufficient personnel were not available; but the progress of the war in Europe during late 1944 and early 1945 and the consequent slackening of the demands on the depots made further efforts to secure more employees unnecessary.

Available statistics on maintenance activity at the subdepots are not particularly enlightening. As explained elsewhere, the subdepots were charged with the responsibility for third echelon repair of locally based aircraft, although in addition they were sometimes assigned manufacturing and modification projects as well. During 1943 a total of 236,622 airplanes, according to ASC statistics, passed through the 200-odd subdepots for repair and all other classes of work.[18] A large number of these airplanes were in the subdepots several times during the year, of course. Some notion of the size of the maintenance staff at a typical subdepot has already been given, but the following table supplies the totals of subdepot maintenance personnel in each of the

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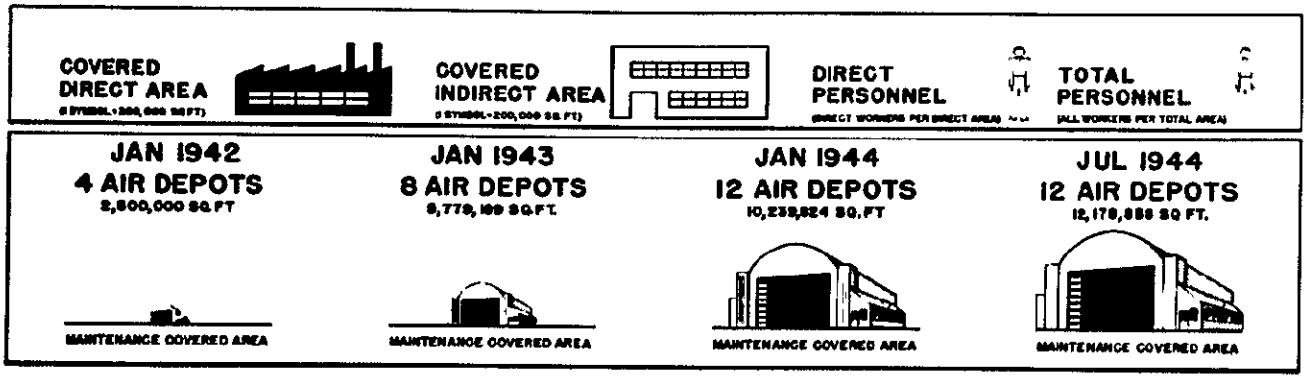
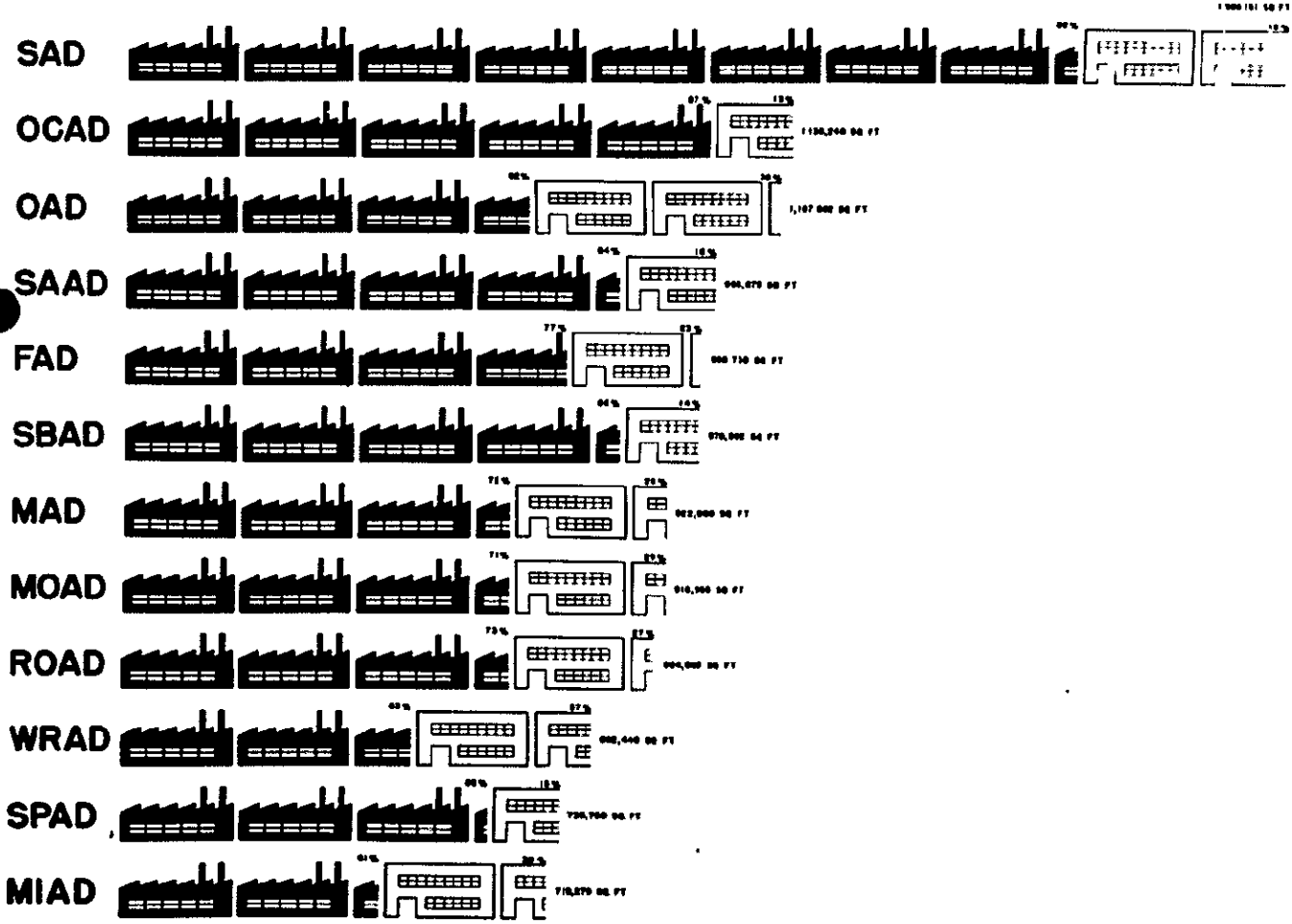
17. The training of a great body of unskilled men and women for depot and subdepot maintenance work was one of the important wartime achievements of the AAF. See "The History of the Procurement, Training, & Retention of Civilian Personnel," Parts I-III.
18. Reports on Airplane Overhaul and Repair by Depots and Sub-Depots, prepared by the Maint. Control Sec., ASC, for Jan.-Dec. 1943, in TSCHI-2 files.

DEPOT MAINTENANCE SHOP AREA

STATUS 1 JULY 1944





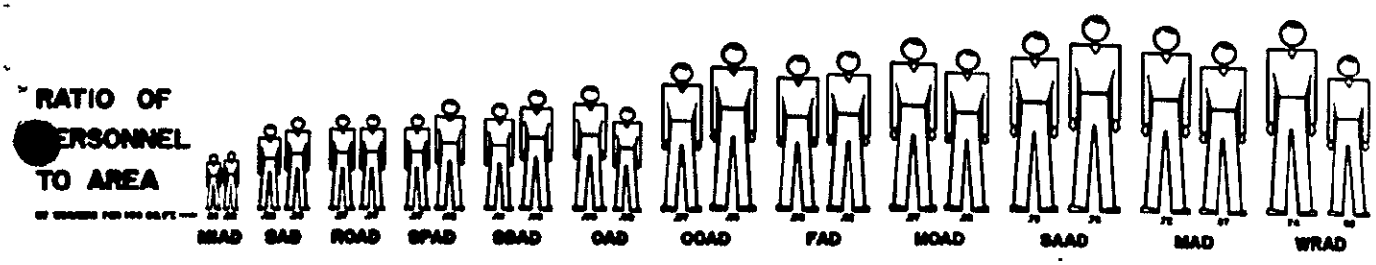


FIGURE 11

control areas for 1942 and 1943.

Subdepot Maintenance Personnel by Control Areas[19]

DATE	F	M	MO	O	OC	R	S	SA	SB	SP	WR	TOTALS
1942	2821	3735	5617	1298			4501	5792				23764
1943	3544	3606	7431	3672	6029	2648	2696	12682	4316	1981	1981	54721

After the absorption of the subdepots 1 January 1944, the maintenance organization at a typical air base consisted of three divisions: the line crews, the PIM organization, where production-line maintenance was used, and the Shop Maintenance and Engineering Unit, formerly the subdepot Maintenance Division. At a large air base like Selman Field, La., to which nearly 200 twin-engine trainers were assigned during 1944, there were as many as 1,600 military and civilian maintenance workers, including both direct and indirect labor. The maintenance squadrons responsible for flight-line work comprised approximately 650 enlisted men, and the PIM Unit, which performed the 50- and 100-hour inspections, about 350 more. In the Shop Maintenance and Engineering Unit, third echelon and miscellaneous work was handled by an average of 220 civilians. The remainder of the 1,600 maintenance personnel were divided among such units as Refueling and Transient Aircraft. During 1944, the PIM Unit completed an average of 250 100-hour and a similar number of 50-hour inspections monthly in addition to various transfer and acceptance inspections. The Shop Maintenance and Engineering Unit performed major repair on approximately 25 airplanes and minor repair on 80 more, and

19. Reports in files of the Personnel Statistics Sec., ATSC; Depot Maintenance Activity Reports.

the Transient Aircraft Unit serviced and repaired from 600 to 1,000 airplanes from other bases.[20]

A check on the efficiency of the various levels of maintenance operations was provided by the results of inspectors' visits and the numerous AAF and ASC routine reports from the field. At the depot level, especially careful records were kept of overhauled engines. A report of June 1944, based on a study of 11,000 engines, expressed the performance of overhauled engines as compared with new engines in terms of ratios.

Engine Performance[21]

Engine type	Average no. hours for new engines	Average no. hours for overhauled engines	Ratio overhauled to new engines
R-1340	781	652	84
V-1650	133	154	116
V-1710	186	168	90
R-1820	491	565	115
R-1830	492	408	83
R-2000	604	501	83
R-2600	346	191	55
R-2800	341	213	62

It may be seen that two engines, the V-1650 and the R-1820, gave more service after the first overhaul than when new, whereas the others, except for the more recently developed engines like the R-2600, gave from 83 to 90 per cent as many flying hours after being overhauled.

Depot and subdepot maintenance activities as a whole were evaluated in terms of the ratio of maintenance personnel to the number of aircraft serviced. Such reports, prepared monthly by the Air Service Command

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20. Station History, Selman Field, 1 September-31 October 1944, pp. 69-97; ibid., 1 November-31 December 1944, pp. 66-79.
21. Lt. Col. Edward G. Kiehle, Acting Chief, Opns. Sec., Maint. Div., ASC, to Chief, Maint. Div., 24 June 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.

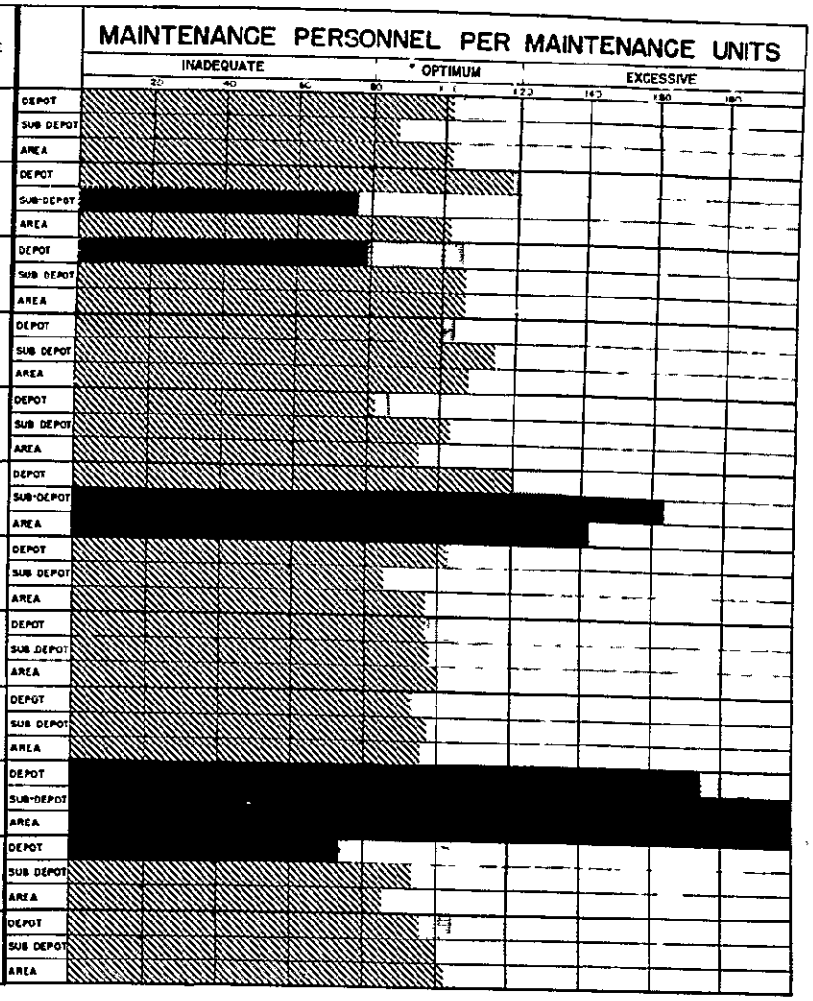
during 1942 and 1943, were based on the "maintenance unit," or the number of man-hours theoretically required to overhaul a primary trainer.[22] That is, the number of airplanes of all types in the various ASC areas were expressed in terms of maintenance units, and the number of depot and subdepot maintenance employees per maintenance unit were computed for each area. In each of the 11 areas in December 1943, for example, there was an average of 3,243 airplanes of various types which, in turn, averaged 6,090 maintenance units. The number of personnel per maintenance unit at both the depots and the subdepots ran from 80 to 120, but in some areas, such as Spokane in December 1943, these figures were considerably higher (see Figure 12).

The maintenance unit was supplanted in 1944 by the "work unit" and also by what was called the "bogy" system. The work unit was a factor obtained by dividing the total man-hours expended on completed jobs at all depots for a given period by the number of jobs. The average thus arrived at was designated the man-hours required per work unit. A similar average was obtained for each of the more important jobs for each type of airplane and engine. On the basis of such figures, bogies, or the approximate number of man-hours considered adequate for many of the depot maintenance jobs, were prepared and held up to the depots as goals to be

22. In 1939, 822 man-hours were considered necessary for the overhaul of a primary trainer. The time between overhauls was generally one and one-half years; hence, an annual maintenance factor of .66 (1 divided by 1-1/2) was set up for this type of airplane. Annual factors were also provided for the other types by dividing the man-hours of work required by 822, the number of man-hours needed for the primary trainer. Brig. Gen. A. W. Robins, Chief, Mat. Div., to Brig. Gen. W. G. Kilner, 23 Jan. 1939, in TSCON 600.121, New Depot Construction, Expansion Program.

RELATIO.., BETWEEN
MAINTENANCE PERSONNEL AND AIRCRAFT SERVED
MONTH ENDED 1 JANUARY 1944

AIR SERVICE COMMAND AREA	AVERAGE AIRPLANES IN AREA EXCLUDING	EQUIVALENT DEPOT MAINTENANCE UNITS	DEPOT MAINTENANCE PERSONNEL	EQUIVALENT SUB-DEPOT MAINTENANCE UNITS	SUB DEPOT MAINTENANCE PERSONNEL	EQUIVALENT AREA MAINTENANCE UNITS	AREA MAINTENANCE PERSONNEL
FAD	2380	6162	*6798*	3550	*3086*	9712	*9884*
MAD	2558	6600	*7903*	4461	*3398*	11061	*11301*
MOAD	4455	7351	*7763*	6504	*6891*	13855	*14654*
OAD	1093	4910	*5049*	3205	*3640*	8115	*8689*
OCAD	5385	8805	*7592*	8249	*8431*	17054	*16023*
ROAD	595	3037	*4049*	1246	*2029*	4283	*6078*
SAD	2874	6305	*6540*	3894	*3310*	10199	*9850*
SAAD	8253	9134	*9694*	12605	*12308*	21739	*22002*
SBAD	3919	4853	*4549*	6683	*6476*	11536	*11025*
SPAD	328	1935	*3641*	552	*2198*	2487	*5839*
WRAD	3832	7857	*6070*	7249	*6719*	15106	*12789*
TOTAL	35672	66949	*69648*	58198	*58486*	125147	*128134*



	DEPOT	SUB DEPOT
GLIDERS AND SINGLE ENGINED BASIC AND ADVANCED TRAINERS, UTILITY TRANSPORTS OBSERVATION AND LIAISON	4	6
TWIN ENGINED ADVANCE TRAINERS AND TWIN ENGINED LIGHT TRANSPORTS	7	15
SINGLE ENGINE FIGHTERS AND BOMBERS	25	24
TWIN ENGINED MEDIUM AND HEAVY TRANSPORTS AND LIGHT BOMBERS	35	28
MEDIUM BOMBERS AND TWIN ENGINED FIGHTERS	45	32
FOUR ENGINED HEAVY TRANSPORTS	60	35
HEAVY BOMBERS	80	40

FIGURE 12

attained in their operations. The man-hour bogy for the DIR of a B-17, for example, was 4,500 hours. For the B-29, it was 7,500 hours, and for the P-38, 3,000 hours.[23] During 1944, the depot maintenance divisions were rated each month on the basis of work units or bogies, and also on the amount of assigned work they actually completed. During the month of June 1944, Ogden was given first place among all the depots, Oklahoma City second, Spokane third, and Fairfield, Mobile, and San Antonio were tied for fourth place. As already mentioned, the AAF inspectors who visited the depot maintenance divisions in late 1944 and early 1945 recommended the elimination of the bogy system on the grounds that, when placed on a competitive basis, the depots tended to report achievements which made a good impression and to minimize their less successful operations.[24] This recommendation was adopted, and in later summaries of depot maintenance activities the ratings were omitted.

In the summer of 1943, the Air Inspector surveyed all commands and air forces, including overseas air forces, on the question of the adequacy of third and fourth echelon maintenance and supply, at that time the responsibility of the Air Service Command. The report summarizing the answers revealed that, of the continental installations, three of the four air forces and the Proving Ground Command were satisfied with third and fourth echelon maintenance and that the Training Command considered maintenance results to be commendable. The Air Transport and the

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23. Work Unit Study, Analysis of Depot Maintenance Activity, prepared by the Maint. Control Sec., ASC, in TSCHI-2 files.
24. Col. John H. Price, Chief, Supply and Maint. Div., Office TAI, to Dir., ATSC, 28 Feb. 1945, in AAG 333.1, Inspections, ATSC.

Antisubmarine Commands, on the other hand, reported maintenance service to be inadequate or unsatisfactory.[25] According to these reports, then, by far the greater number of airplanes in the United States at that time were receiving the higher echelons of maintenance to the satisfaction of the using organizations.

In addition to the above evaluations of activities at the depots and subdepots, a check on maintenance efficiency was supplied in routine reports, particularly the reports on airplanes out of commission.[26] The total inventory of tactical and trainer airplanes in the United States and the total grounded month by month from 1943 through June 1945 appear on the accompanying tables (see Figures 13 and 14). The same tables show the percentages of airplanes undergoing maintenance at ASC installations alone.[27] A steady improvement in depot efficiency can be noted in the downward trend of these percentages beginning in January 1944.

Whereas the figures just cited report only the airplanes grounded for fourth echelon maintenance, the following table gives the percentages of the domestic inventory grounded for all echelons of maintenance, including repairs, alterations, and inspections. These percentages, then, reflect better than any other statistics the maintenance achievements of the AAF within the continental United States.

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25. "Questionnaire on Effectiveness of Maintenance: 1944," in AFSHO files.
26. The Daily Aircraft Status and Flying Time Report, AAF Form 110, included the number of hours during each day when the airplane was grounded for maintenance and maintenance inspections. Each flying organization was required to submit these reports daily. AAF Reg. 15-110, 1 Aug. 1944.
27. The percentages given for airplanes grounded for maintenance during 1943 include both depot and subdepot operations; those given for 1944 and 1945 include depots only, inasmuch as the subdepots were transferred from ASC jurisdiction as of 1 January 1944.

PERCENTAGE OF AAF TRAINER AIRPLANES OUT OF COMMISSION

(Within Continental United States)

Showing TOTAL OUT of COMMISSION and SUPPLY and MAINTENANCE RESPONSIBILITY

Data Compiled as Monthly Averages

Year	STATUS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1943	TOTAL TRAINER INVENTORY	17,270	18,333	19,273	19,761	20,349	21,302	22,144	22,658	23,430	24,394	25,252	25,712
	TOTAL GROUNDED	2,396	2,911	2,767	2,787	2,969	3,426	3,716	3,698	3,947	3,985	4,502	4,141
	% of Inventory	13.9	15.9	14.4	14.6	14.6	16.1	16.8	16.3	16.8	16.3	17.8	16.1
	ASC RESPONSIBLITY for GROUNDINGS - TOTAL (a)	1,175	1,645	1,553	1,539	1,538	1,796	1,793	1,923	1,743	1,718	1,876	1,641
	% of Inventory	6.8	9.0	8.1	7.8	7.6	8.4	8.1	8.5	7.4	7.0	7.4	6.4
	Grounded for PARTS	745	966	862	854	947	894	898	987	b 1,050	1,018	1,072	826
	% of Inventory	4.3	5.3	4.5	4.3	4.7	4.2	4.1	4.4	b 4.5	4.2	4.2	3.2
	Grounded for MAINTENANCE	397	633	627	665	567	891	871	858	b 693	659	753	774
	% of Inventory	2.3	3.5	3.3	3.4	2.8	4.2	3.9	3.8	b 2.9	2.7	3.0	3.0
	Grounded for MODIFICATION	33	46	64	20	24	11	24	78	0	41	51	41
	% of Inventory	0.2	0.2	0.3	0.1	0.1	(d)	0.1	0.3	0.0 (e)	0.1	0.2	0.2
1944	TOTAL TRAINER INVENTORY	26,086	26,578	26,997	27,333	27,579	27,671	27,488	26,734	23,196	20,006	17,612	16,671
	TOTAL GROUNDED	4,163	4,025	4,219	5,086	5,571	6,552	8,026	7,672	4,004	3,651	2,894	2,736
	% of Inventory	16.0	15.1	15.6	18.6	20.2	23.7	29.2	28.7	17.3	18.2	16.4	16.4
	ASC RESPONSIBILITY for GROUNDINGS - TOTAL (a)	c 1,115	897	722	488	472	432	435	516	439	408	381	364
	% of Inventory	c 4.3	3.4	2.7	1.8	1.7	1.5	1.6	1.9	1.9	2.0	2.1	2.2
	Grounded for PARTS	724	535	400	295	295	253	256	254	249	261	268	295
	% of Inventory	2.8	2.0	1.5	1.1	1.1	0.9	0.9	0.9	1.1	1.3	1.5	1.8
	Grounded for MAINTENANCE	(c) 370	357	322	192	170	175	177	258	185	141	112	68
	% of Inventory	(c) 1.4	1.4	1.2	0.7	0.6	0.6	0.7	1.0	0.8	0.7	0.6	0.4
	Grounded for MODIFICATION	21	5	(d)	1	7	5	2	4	5	5	(-)	1
	% of Inventory	0.1	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(d)	(-)	(d)
1945	TOTAL TRAINER INVENTORY	15,808	14,500	14,041	13,396	12,086							
	TOTAL AOC	2,509	3,038	3,513	3,528	3,368							
	% of Inventory	16.5	21.0	25.0	26.3	27.9							
	ASC RESPONSIBILITY for AOC - TOTAL (a)	391	532	578	293	307							
	% of Inventory	2.4	3.6	4.1	2.2	2.5							
	AOC for PARTS	237	210	217	259	268							
	% of Inventory	1.5	1.4	1.5	1.9	2.2							
	AOC for MAINTENANCE	150	312	360	32	38							
	% of Inventory	0.9	2.2	2.6	0.3	0.3							
	AOC for MODIFICATION	4	10	1	2	-							
	% of Inventory	(d)	(d)	(d)	(d)	-							

SOURCE: SU-A-155-2 Semi-Monthly Digest of Trainer Aircraft Status.

NOTES:
(a) Does not include planes crated or grounded for other reasons.
(b) Planes grounded for both parts and maintenance transferred from AGM to AGP by new AAF Regulation No. 15-110.
(c) Sub-depots transferred to other commands.
(d) Less than 1 or 0.1%.
(e) Percentages now based on total plane days on hand instead total aircraft on hand. Aircraft grounded now redefined as aircraft out of commission under AAF Reg. No. 15-110, dated 1 Aug 44.

Statistical Control Office, Management Control Headquarters, Air Technical Service Command

FIGURE 14

TABLE AS-2

Revised 13 Jun 1945

TABLES AS-1

PERCENTAGE OF AAF TACTICAL AIRPLANES OUT OF COMMISSION

(Within Continental United States)

Showing TOTAL OUT of COMMISSION and SUPPLY and MAINTENANCE RESPONSIBILITY

Data Compiled as Monthly Averages

YEAR	STATUS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1943	TOTAL TACTICAL INVENTORY	10,470	11,786	12,466	13,447	13,889	14,059	15,160	16,337	17,452	18,663	20,103	21,148
	TOTAL GROUNDED	4,750	4,921	5,042	5,434	5,626	6,089	6,568	7,097	7,188	7,609	8,021	7,968
	% of Inventory	43.3	41.8	40.4	40.4	40.5	43.3	43.3	43.4	41.2	40.8	39.9	37.8
	ASC RESPONSIBILITY for GROUNDINGS - TOTAL (a)	1,970	1,874	1,993	2,222	2,338	2,480	2,604	2,790	2,906	3,147	3,027	2,847
	% of Inventory	18.0	15.9	16.0	16.5	16.8	17.6	17.2	17.1	16.7	16.9	15.1	13.5
	Grounded for PARTS	929	940	1,041	1,030	1,047	1,069	1,077	1,167	(b)1,561	1,595	1,430	1,328
	% of Inventory	8.5	8.0	8.4	7.7	7.5	7.6	7.1	7.1	9.0	8.6	7.1	6.3
	Grounded for MAINTENANCE	873	738	726	877	1,032	1,193	1,243	1,305	(b)1,026	1,306	1,284	1,223
	% of Inventory	8.0	6.2	5.8	6.5	7.4	8.5	8.2	8.0	(b) 5.9	7.0	6.4	5.8
	Grounded for MODIFICATION	168	196	226	315	259	218	284	318	319	246	313	296
	% of Inventory	1.5	1.7	1.8	2.3	1.9	1.5	1.9	2.0	1.8	1.3	1.6	1.4
1944	TOTAL TACTICAL INVENTORY	22,114	22,630	23,087	23,075	23,198	24,046	24,545	24,555	24,991 (d)	24,546	24,220	24,245
	TOTAL GROUNDED	8,524	8,304	8,897	8,844	9,383	10,436	10,967	11,347	10,226	10,179	9,710	9,714
	% of Inventory	38.5	36.7	38.5	38.3	40.4	43.4	44.7	46.2	40.9	41.5	40.1	40.1
	ASC RESPONSIBILITY for GROUNDINGS - TOTAL (a)	(c)1,750	1,656	1,404	1,338	1,447	1,343	1,346	1,371	1,586	1,852	1,707	1,763
	% of Inventory	(c) 7.9	7.3	6.1	5.8	6.4	5.6	5.5	5.6	6.3	7.6	7.0	7.3
	Grounded for PARTS	1,127	1,098	906	866	824	755	770	868	1,011	1,070	1,095	1,080
	% of Inventory	5.1	4.9	3.9	3.8	3.6	3.1	3.1	3.3	4.0	4.4	4.5	4.5
	Grounded for MAINTENANCE	(c) 454	463	425	428	597	549	501	508	494	548	539	613
	% of Inventory	(c) 2.1	2.0	1.9	1.8	2.6	2.3	2.1	2.1	2.0	2.2	2.2	2.5
	Grounded for MODIFICATION	169	95	73	44	56	39	76	55	81	234	76	70
	% of Inventory	0.7	0.4	0.3	0.2	0.2	0.2	0.3	0.2	0.3	1.0	0.3	0.3
1945	TOTAL TACTICAL INVENTORY	24,556	24,376	23,838	23,149	22,986	24,289						
	TOTAL AOC	9,894	9,952	10,022	9,812	9,724	10,109						
	% of Inventory	40.3	40.8	42.0	42.4	42.3	41.6						
	ASC RESPONSIBILITY for AOC - TOTAL (a)	1,694	1,706	1,654	1,779	1,789	1,851						
	% of Inventory	6.9	7.0	6.9	7.7	7.8	7.6						
	AOC for PARTS	988	994	939	896	934	874						
	% of Inventory	4.0	4.1	3.9	3.9	4.1	3.6						
	AOC for MAINTENANCE	618	577	564	606	716	847						
	% of Inventory	2.5	2.4	2.4	2.6	3.1	3.5						
	AOC for MODIFICATION	89	135	151	277	139	131						
	% of Inventory	0.4	0.5	0.6	1.2	0.6	0.5						

SOURCE: SU-A-155-1 Quarter Monthly Digest of Tactical Aircraft Status.

NOTES:
(a) Does not include planes crated or grounded for other reasons.
(b) Planes grounded for both parts and maintenance transferred from AGM to AGP by new AAF Regulation No. 15-110.
(c) Sub-depots transferred to other commands.
(d) Percentages now based on total plane days on hand instead total aircraft on hand. Aircraft grounded now redefined as aircraft out of commission under AAF Regulation No. 15-110, dated 1 August 1944.

Statistical Control Office, Management Control
Headquarters, Air Technical Service Command

CONFIDENTIAL

FIGURE 13

TABLE AS-1
Y-12814
Revised 14 Jul 1945

Percentage of Aircraft in Continental United States Grounded for Maintenance, Repair, Alteration, and Inspections[28]

31 December 1943	18.8
30 June 1944	21.5
31 December 1944	19.8
30 June 1945	17.9

Despite the fact that the percentage of tactical aircraft out of commission for all causes including maintenance remained steadily at approximately 40 per cent throughout the period 1943-1945 while the percentage of trainers out of commission tended to rise (see Figures 13 and 14), it may be seen that the proportion of airplanes grounded for maintenance alone decreased perceptibly after the middle of 1944.

28. Statistics based on Form 110, Office of Statistical Control, Hq., AAF.

Chapter VII

CONCLUSIONS

The rapid expansion of the Army Air Forces necessitated a corresponding enlargement of existing maintenance organizations. At AAF Headquarters in Washington in 1939, the maintenance responsibilities of the chief of the air arm devolved upon a small office in the Supply Division. Several organizational changes occurred thereafter, and in March 1943 maintenance supervision was vested in the Supply and Maintenance Branch under the Assistant Chief of Air Staff, M&D, later M&S. This branch, to which 140 civilian and military personnel were assigned as of 30 June 1945, received routine reports from the several commands and air forces, passed down staff decisions, and formulated broad policies pertaining to maintenance and supply.

In 1939, AAF Headquarters supervision of maintenance operations was, to a considerable extent, channeled through the Maintenance Branch of the Field Service Section, a unit of the Materiel Division at Wright Field. The responsibilities of this branch included the preparation of technical instructions, the study of maintenance procedures, the processing of Unsatisfactory Reports, and, in conjunction with the Engineering Division, the investigation of failures. In addition, the Chief of the Materiel Division, through the Field Service Section, exercised command control over the four air depots at which the overhaul of flying equipment was performed. In February 1940, the Maintenance Branch was staffed by

42 civilians and officers. The need for increasing the prestige of the Field Service Section was recognized early in the expansion program, and in 1941 it became the principal component of the Maintenance Command, later renamed the Air Service Command and removed from the jurisdiction of the Chief of the Materiel Division. After a number of organizational shifts, in the course of which the Field Service Section lost its identity, the greatly augmented maintenance unit came to be known as the Maintenance Division and, as of 30 June 1945, comprised a total of 1,921 civilians and officers. While these changes were going on, the maintenance and supply facilities of the four original depots were considerably extended and eight new depots were constructed in the continental United States, all but one of which were in operation by the end of 1943.

According to plan, the Provisional Air Corps Maintenance Command, upon its activation in March 1941, was to assume full control not only of the air depots and their maintenance and supply operations, but also of third echelon repair at the air bases. The latter responsibility was discharged by the establishment at all important bases of civilianized subdepots, the commanders of which were answerable to the Maintenance Command (later the Air Service Command) through the air depots. Although the air base commanders retained control of the servicing and minor repair (first and second echelon maintenance) of their airplanes, except for the technical supervision reserved for the Air Service Command, the fact that the third echelon facilities located on their bases were not directly subject to their command proved to be a source of difficulty. The principle of parallel chains of command, as expressed in the new division of maintenance and supply responsibilities, came into conflict with the

principle of unified command. The conflict began with the reluctance of the old GHQ Air Force to permit another command to control installations on its bases and continued until 1 January 1944 when the subdepots were transferred to the air forces and commands using their facilities. Thereafter, the Air Service Command (after 1 September 1944, the Air Technical Service Command) exercised command control only at the 12 air depots and no more than technical supervision over the first, second, and third echelon maintenance carried on by the various air forces and commands at their air bases.

There were other important developments in the administration of maintenance, among which was the absorption of certain maintenance responsibilities and personnel of the Other Arms and Services, like the Signal Corps and the Ordnance Department. The AAF, by a more or less gradual process, acquired a large measure of control over the maintenance of equipment furnished by the Other Arms and Services; and to supplement the facilities of the air depots, contracts were made with a number of commercial enterprises for the overhaul of trainer airplanes and engines, and with airlines for the reconditioning of Air Transport Command equipment.

During the period 1939-1945, maintenance policies were formulated much as they had been during the prewar years. The main outlines of the maintenance system were defined in directives prepared by Headquarters, AAF, whereas technical instructions were issued by Wright Field. The prescribed policies and procedures could be kept abreast of needs only when a steady flow of information from the operating organizations was maintained. Such data reached Wright Field and Headquarters, AAF in

the form of reports of inspections, Unsatisfactory Reports, conferences, the Monthly Report of Depot Maintenance Activity, and various statistical reports, such as AAF Form No. 110. As a result of the war, there was an enormous increase in the number of UR's submitted and also in the number and variety of conferences on maintenance problems.

The basic maintenance policies were the visual inspection system, depot inspection and repair, and obsoletion. So far as visual inspection was concerned, the most fundamental change during the period 1939-1945 was the lengthening of the inspection intervals in July 1941 from 20, 40, and 80 hours to 25, 50, and 100 hours. Also, special Inspection and Maintenance Guide came to be published for each important airplane model. The principal change revealed in the directives prescribing depot inspection and repair was the redefinition of the echelons of maintenance. Only three echelons were distinguished prior to February 1942, but in a Technical Order issued that month, servicing and minor repair, formerly first echelon, were listed as first and second echelon respectively; subdepot operations, originally second echelon, as third; and depot operations, formerly third, as fourth echelon. Also, as a result of improvements in construction, changes were effected in the recommended inter-overhaul periods for engines, but the policy of reconditioning airplanes only when inspections disclosed the need for such work rather than on a predetermined schedule remained in force.

The obsoletion policy in effect in 1939 permitted a total life of 10 years for airplanes, but the various types of combat airplanes became obsolete after a stated period of service varying from six to eight years, and were thereafter not considered suitable for their original

military purpose. In 1943, this policy was changed to permit rendering items of equipment obsolete whenever superior equipment was available. The Commanding General, AAF was authorized to make the declaration upon recommendations from the engineering activities at Wright Field.

Maintenance procedures, including inspections and the various echelons of repair, underwent considerable change. The daily, preflight, and 25-hour inspections and the incidental minor repair were not basically affected, but the performance of all other inspections and higher echelons of maintenance was radically changed because of the application of advanced industrial production methods. At training fields the 100-hour, 50-hour, and sometimes the 25-hour inspections as well were conducted by specialized personnel on a production-line basis. Production-line maintenance was also employed for the inspection and minor repair of combat airplanes at many air bases. In the subdepots--later known as Shop Maintenance and Engineering Units--production methods were used to some extent, especially in the overhaul of accessories. The maintenance divisions of the air depots, however, afforded the widest opportunity for the establishment of progressive overhaul and assembly lines. Conveyorized units, manned by personnel trained to perform one or two specific operations, were set up for engine overhaul, the reconditioning of parts and accessories, and even some phases of airplane DIR. Not all jobs lent themselves to production-line methods, of course. The war years also saw a great increase in the development and use of specialized tools and equipment at all levels of maintenance operations. Maintenance personnel were constantly encouraged by rewards and other devices to submit ideas for better tools and more efficient methods. Other important maintenance developments

were the specialization and localization of repair projects at the various air depots, the extensive modification activities, and the storage of excess aircraft.

Domestic airplane inventories rose from approximately 2,400 in 1939 to over 50,000 in 1944, then receded to 38,000 by June 1945; and engine inventories during the same period grew from fewer than 6,000 to nearly 160,000. Many of these engines had been returned from overseas theaters for overhaul. The amount of reparable equipment increased accordingly until in 1944 nearly 17,000 airplanes and 107,000 engines passed through the 12 air depots for repair and overhaul. In addition, the contract overhaul agencies and the airlines shops overhauled a considerable quantity of trainer and Air Transport Command equipment. A great volume of repair and modification was handled in the 230-odd subdepots, later absorbed by the air bases. Also at each of the air bases were maintenance squadrons which performed servicing, inspection, and minor repair; and at many fields PIM units were organized to conduct inspections and minor repair.

In 1939, the four air depots then in operation employed approximately 1,800 maintenance workers; but by 1944 over 60,000 employees were required to carry the work load at the 12 depots, and at the 216 civilianized subdepots were 54,000 more. To ascertain the number of military personnel at each base whose principal duties were flight-line work, minor repair, and the inspection of airplanes would be very difficult. It may be conservatively estimated, however, that there was an average of at least four enlisted men per airplane assigned to the air bases for this work.

The efficiency of the entire AAF maintenance program may best be gauged by statistics on airplanes out of commission for maintenance. These figures, available only from 1943, reveal a steady decrease from a high of 21.5 per cent in June 1944 to 17.9 per cent in June 1945. The percentage of airplanes grounded for depot repair alone decreased from 8.5 per cent for tactical aircraft in June 1943 to between 3 and 4 per cent during 1944 and the first half of 1945. Thus, notwithstanding the tremendous problems entailed by the more than 20-fold expansion of the AAF, maintenance efficiency actually improved somewhat during the war years. Perhaps the most important reasons for the fact that the quality of maintenance improved rather than deteriorated were (1) the vigorous program of mechanic training carried on throughout the war, (2) the development of production-line maintenance, and (3) careful supervision of the engineering standards met by depot overhaul activities.

The most critical problem so far as maintenance was concerned resulted from the extreme shortage of trained mechanics. At the depot and subdepot level, this shortage was met principally by the expedient of training many thousands of unskilled civilians, including women. The rapid development of progressive overhaul facilities was also of importance in alleviating the difficulties because unskilled men and women could be taught one or two simple assembly-line operations far more rapidly than they could be made into competent all-round mechanics. Progressive overhaul was also responsible for a greater output per worker so long as a steady flow of reparables could be sustained, and with shop inspectors checking the work at every step, even for some improvement in the quality of the product. One of the disadvantages of the system was the dislocation resulting from

the absence from work of assembly-line personnel specialized in particular operations. At the air bases, the shortage of enlisted mechanics was equally critical, and it was met in substantially the same fashion. Elaborate training programs were inaugurated, and at many bases, inspections and minor repair came to be conducted on the production-line plan. In addition, a large number of old line and crew chiefs were commissioned as engineering officers just as old depot employees were advanced to important supervisory positions.[1] Despite the measures just described, it was reported as late as November 1944 that a shortage of maintenance personnel existed in the continental air forces. It was acknowledged at the same time, however, that the use of production-line maintenance alleviated the effects of the shortage to a considerable extent.[2]

The inadequacy of maintenance facilities throughout the United States was another critical problem in 1941 and 1942. Larger and larger construction programs succeeded each other, however, until the four old depots had been expanded and modernized, eight new depots constructed, and repair hangars and shops erected at more than 200 air bases. By the end of 1944 it appeared that depot capacity had been increased beyond the availability of acceptable personnel, inasmuch as the newest installation, Miami, was never fully manned or fully utilized. It also seems probable that the subdepots were expanded beyond actual maintenance needs, since there were many reports of idle personnel and even some competition for work projects among the subdepots as early as 1944. In

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1. R&R, Maj. Gen. Muir S. Fairchild, to TAI, 4 Nov. 1942, in TSAGD 452.031, Miscellaneous Maintenance and Repair.
2. Daily Activity Report to Gen. Arnold, by AC/AS, CC&R, 27 Nov. 1944.

the light of the uncertainty about future requirements that must prevail during wartime, however, a degree of overexpansion is cause for approbation rather than for reproach.

There were many other problems that had to be faced during the period 1939-1945. One grave difficulty, particularly during 1942, was the shortage of parts for maintenance--primarily a supply problem. Another problem had to do with the administration of depot operations. In the opinion of some depot administrators, there was a tendency on the part of the Air Technical Service Command to shift work projects among the depots without due notice. For example, San Bernardino was instructed to prepare for the production-line overhaul of R-1830 engines early in 1944 and accordingly went ahead with the necessary training. Before the work was begun, however, the project was canceled, and a bad morale situation resulted at the depot.[3] The administration of the subdepots up to the time of their absorption by the air bases was still another problem for reasons already discussed.

It is apparent from the foregoing survey of the maintenance of army aircraft that, despite the great expansion and the innovations necessary for fighting a victorious war, there were few breaks in the continuity of the basic policies. The most important departure from established procedures was the attempt to centralize control of third as well as of fourth echelon maintenance by the creation of the subdepot system, an attempt that was given up because of administrative difficulties. Again, contracts were given to commercial enterprises for the overhaul of

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3. Col. J. G. Taylor, CO, SBASC, to CG, ASC, 1 April 1944, in TSAGD 452.031, Maintenance and Repair of Aircraft and Aeronautical Equipment.

airplanes and engines, but this abandonment of tradition was always regarded as a temporary expedient and all contracts were canceled as soon as AAF facilities were available for carrying the full maintenance load. Otherwise, wartime maintenance activities in the United States represented a straight-line development of the concepts established during the preceding 20 years.

G L O S S A R Y

AAG	Air Adjutant General
AC/AS, M&S	Assistant Chief of Air Staff, Materiel and Services
AC/AS, MM&D	Assistant Chief of Air Staff, Materiel, Maintenance, and Distribution
AC/AS, OC&R	Assistant Chief of Air Staff, Operations, Commitments, and Requirements
AFDMR	Director of Military Requirements, Hq., AAF
AFRBS	Director of Base Services, Hq., AAF
AFSHO	Historical Office, Hq., AAF
AG	Adjutant General
AR	Army Regulation
ASC	Air Service Command
ATC	Air Transport Command
ATSC	Air Technical Service Command
C/AC	Chief of Air Corps
DIR	Depot Inspection and Repair
F	Fairfield
FAD	Fairfield Air Depot
FASC	Fairfield Air Service Command
FATSC	Fairfield Air Technical Service Command
GHQ AF	General Headquarters Air Force
GO	General Orders
M	Middletown
MAD	Middletown Air Depot
MATSC	Middletown Air Technical Service Command
MI	Miami
MIAD	Miami Air Depot
MO	Mobile
MOAD	Mobile Air Depot
MOADCAC	Mobile Air Depot Control Area Command
MOASC	Mobile Air Service Command
O	Ogden
OAD	Ogden Air Depot
OASC	Ogden Air Service Command
OATSC	Ogden Air Technical Service Command
OC	Oklahoma City
OCAC	Office of Chief of Air Corps
OCAD	Oklahoma City Air Depot

PLM	Production Line Maintenance
R	Rome
RAD	Rome Air Depot
R&R	Routing and Record Sheet
r.p.m.	revolutions per minute
S	Sacramento
SA	San Antonio
SAAD	San Antonio Air Depot
SAADCAC	San Antonio Air Depot Control Area Command
SAATSC	San Antonio Air Technical Service Command
SAD	Sacramento Air Depot
SB	San Bernardino
SBAD	San Bernardino Air Depot
SBASC	San Bernardino Air Service Command
SP	Spokane
SPAD	Spokane Air Depot
TAG	The Adjutant General
TAI	The Air Inspector
TM	Technical Manual
TO	Technical Order
TSAGD	Hq., ATSC, Adjutant General's Section, Records Branch, Central Files
TSBFO	Budget and Fiscal Office Files, Hq., ATSC
TSCHI-2	Historical Office, Area A, Hq., ATSC
TSCON	Construction Office Files, Hq., ATSC
TSPCP	Personnel Division Files, Hq., ATSC
UR	Unsatisfactory Report
WAR	Weekly Activity Report
WD	War Department
WR	Warner Robins
WRAD	Warner Robins Air Depot
WRASC	Warner Robins Air Service Command

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